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1-82(U) MARINE CORPS TACTICAL SYSTEMS SUPPORT ACTIVITY
CAMP PENDLETON CA D P AMIOTTE 23 JUL 82

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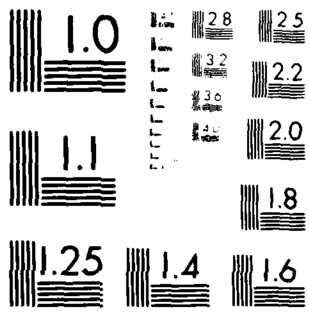

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18. SUPPLEMENTARY NOTES

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This document is a combined test plan and test report for the CAMPS Test 1-82. The test investigated the benefits of the CAMPS to the mission planning process using probability of survival as a measure of performance. In addition, data was collected and analyzed to assess the utility of the CAMPS as currently configured. Test design and administration, data management and analysis, results, conclusions, and recommendations are presented.

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COMPUTER-AIDED MISSION PLANNING SYSTEM (CAMPS) TEST 1-82 TEST REPORT

MCTSSA

MARINE CORPS BASE
CAMP PENDLETON, CA 92055

23 JULY 1982

Test Report 01

Computer-aided Mission Planning System (CAMPS)
Test 1-82

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23 July 1982

Analysis Section
Tactical Systems Development Branch
Marine Corps Tactical Systems Support Activity
Camp Pendleton, California

EXECUTIVE SUMMARY

This document is a combined test plan and test report for the CAMPS test 1-82. The purpose of the CAMPS Test 1-82 was to investigate the mission planning benefits and the utility of CAMPS, a Computer-aided Mission Planning System.

There were two facets to the CAMPS Test 1-82. One was the investigation of the benefit arising from the use of the CAMPS over the current manual technique. The other was the collection of data to estimate the utility of the CAMPS as it is currently configured.

In order to investigate the benefits of the CAMPS to the mission planning process, tactical flight routes were developed by test participants using both manual techniques and using the CAMPS. Each of these flight routes was then evaluated using a system called the Experimental Penetration and Analysis Support System (EPASS). A probability of survival for each mission was derived using the probability of sustaining abort level damage provided by the EPASS. The difference in the probabilities of survival for missions planned with the CAMPS and missions planned manually was then computed for each participant and used as the measure of benefit provided by the CAMPS.

The utility of the CAMPS was investigated using the subjective responses of the test participants on various questionnaires. The results of the questionnaires were summarized and presented in the appendices.

The key result of the CAMPS Test was that analysis of the resulting probabilities of survival made it possible to reject the hypothesis that CAMPS planning is not more effective than manual planning at the following levels of significance:

To the Target $p = .032$

Total Mission $p = .052$

What this and the data imply is that an improvement in the probability of survival of about 25% can be anticipated when using the CAMPS as compared to manual methods.

Overall the system was well received by the naval aviators and naval flight officers of MAG-13 at El Toro, California. The utility of the system was rated very high with suggestions for improvement being offered and detailed in the report.

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SECTION 1

INTRODUCTION

1.1 BACKGROUND

1.1.1 General

The Marine Corps is currently involved in the procurement of a prototype automated tactical aircraft mission planning aid called CAMPS (Computer Aided Mission Planning System). It is the intention of the Marine Corps to use this system for training and exercises in order to more clearly define the requirements for such a system in the Fleet Marine Force (FMF). It is to this end that the test described in this document was designed and conducted. It is one in a series of evaluation efforts envisioned to confirm those aspects of CAMPS needed, and redefining those areas requiring modification before implementation in the Marine Corps.

1.1.2 Description of CAMPS

CAMPS is a microcomputer-based system. It uses color graphics technology, a terrain elevation data base, and enemy surface-to-air missile (SAM) data (currently unclassified) to present to the tactical mission planner a view of the enemy SAM threat. This depiction of the SAM threat has been modified to indicate the effects of terrain masking and aircraft altitude on the capabilities of the SAMs. To develop a flight plan, the planner designates an altitude and is then presented a view of the enemy SAM threat at that altitude. He then plans a route by specifying checkpoints that allow him to avoid the greatest concentration of enemy threat as indicated by the threat boundaries (indicating effect of terrain masking) and the color coding of areas around the sites.

Upon completion of a route, the CAMPS computes the coordinates of the checkpoints, time checks, and fuel usage data, then prints this route information in a kneeboard card format.

Threat capability parameters, aircraft performance specifications, and the terrain data base can be varied to support operations in any scenario.

1.1.3 Previous Tests

Previous tests using the CAMPS/EPASS or earlier versions of the same system consisted of a manual/automated test conducted under tasking from the Marine Corps Operations Analysis Group (MCOAG). The purpose of the test was to measure the benefit of automation in mission planning, both for aviation and ground. The results were used for a Cost and Operational Effectiveness Analysis (COEA) of the Tactical Combat Operations (TCO) System. CAMPS itself was not tested, however it was used as a device to simulate an automated aid to planning. Its objectives were very similar to Objective 1 of this test although the testing procedure was radically different.

A first effort at evaluating CAMPS itself was recently conducted at Marine Aircraft Wing Training Squadron-1 (MAWTS-1) at Yuma, Arizona; where data was

collected on the system. Most of Objectives 2 through 8 of CAMPS Test 1-82 were supported by the MAWTS-1 data collection effort.

1.2 TEST PURPOSE

The purpose of CAMPS Test 1-82 is to provide data and associated analysis on the mission planning benefits and the utility of the CAMPS (as currently configured) against a specified threat level. Data will be used as a basis for planning of future tests and further development of CAMPS. Data is meant to be combined with the test results of future testing in order to contribute to decisions concerning procurement.

1.3 TEST OBJECTIVES

1.3.1 Objective 1

To investigate whether a plan for a tactical air strike mission developed using CAMPS results in a higher probability of survival than one developed manually.

1.3.2 Objective 2

To assess test participant attitudes regarding the number of required altitude slices and the specific altitudes preferred.

1.3.3 Objective 3

To assess test participant attitudes regarding the physical appearance and information content of the CAMPS display.

1.3.4 Objective 4

To assess the user compatibility of the current CAMPS kneeboard card.

1.3.5 Objective 5

To assess the ease of planning with CAMPS.

1.3.6 Objective 6

To assess the marginal value of adding Experimental Penetration and Analysis Support System (EPASS) type capabilities to the CAMPS.

1.3.7 Objective 7

To assess the user's overall opinion of the CAMPS/EPASS system as a mission planning tool.

1.3.8 Objective 8

To compile a list of participant likes and dislikes about the CAMPS/EPASS.

SECTION 2

TEST DESIGN

2.1 APPROACH

There were two facets to the CAMPS Test 1-82. One was the investigation of the benefit arising from the use of the CAMPS over the current manual technique. The other was the collection of data to estimate the utility of the CAMPS as it is currently configured.

In order to investigate the benefits of the CAMPS to the mission planning process, tactical flight routes were developed by test participants using both manual techniques and using the CAMPS. Each of these flight routes was then evaluated using another COMARCO, Inc. system called the Experimental Penetration and Analysis Support System (EPASS). Details of the evaluation procedure are contained in Appendix A. A probability of survival for each mission was derived using the probability of sustaining abort level damage provided by the EPASS. The difference in the probabilities of survival for missions planned with the CAMPS and missions planned manually was then computed for each participant and used as the measure of benefit provided by the CAMPS.

The utility of the CAMPS was investigated using the subjective responses of the test participants on various questionnaires. The results of the questionnaires were summarized and used to meet Objectives 2 through 8.

2.2 FACTORS

The factors and the levels of each factor (in parentheses) considered in the design of the CAMPS test were:

Planning System (CAMPS;Manual)
Order of Testing (Manual/CAMPS) (CAMPS/Manual)
Test Participant (1-24)
Target (1,2)
Level of Threat (Constant)
Aircraft Used (Constant)
Intelligence Reliability (Constant)

2.2.1 Planning System

As Objective 1 states, the key point of investigation is the difference between the CAMPS, an automated system, and the manual system of mission planning. Therefore, the type of planning system used to prepare a flight route was chosen as the dependent variable for Objective 1.

2.2.2 Order of Testing

The two levels of this factor, the CAMPS/Manual order and the Manual/CAMPS order, were distributed in the test layout in a balanced manner. This was accomplished by having the odd-number participants use the CAMPS/Manual order and the even-number participants use the Manual/CAMPS order. Both orders were used in an effort to reduce the effect of learning associated with the

consistent presentation of either of the system's information prior to planning with the other system.

2.2.3 Test Participant

The greatest degree of variability was anticipated among the test participants. This was controlled by having each participant act as his own control and by the number of test participants used. Table 2-1 shows the distribution of the 24 test participants amongst the various combinations of factors.

Table 2-1. Test Lay-out

Planning System -->	CAMPS		MANUAL	
Order of Testing -->	CAMPS/ MANUAL	MANUAL/ CAMPS	MANUAL/ CAMPS	CAMPS/ MANUAL
Target 1	1 5 9 13 17 21	4 8 12 16 20 24	4 8 12 16 20 24	1 5 9 13 17 21
Target 2	3 7 11 15 19 23	2 5 10 14 18 22	2 6 10 14 18 22	3 7 11 15 19 23

2.2.4 Target

Since each test participant planned two flight routes, it was necessary to have two different targets with different starting points so that each planning effort might produce a different route. Details of the targets used can be found in Appendix B. The two targets were assigned in a balanced manner so that a planning system, order of testing, and target combination occurred with equal frequency.

2.2.5 Constant Factors

In an effort to control the effect of some of the other independent variables: the level of threat, the aircraft used, and intelligence reliability were held constant over all iterations. For the test, perfect intelligence was assumed. Further details on these factors can be found in the scenario contained in Appendix B.

2.3 MEASURES OF PERFORMANCE (MOPs)

2.3.1 Objective 1

2.3.1.1 MOP 1a

The difference in the probability of survival (between CAMPS and manual plans) from the start of the mission to the target.

2.3.1.2 MOP 1b

The difference in the probability of survival from the start of the mission to the end of the mission.

2.3.2 Objective 2

2.3.2.1 MOP 2a

Test participant opinions of the minimum number of altitude slices required to perform mission planning.

2.3.2.2 MOP 2b

The "Relative Worth" of altitude slices as determined from test participant preferences under diminishing resources.

2.3.3 Objective 3

2.3.3.1 MOP 3a

Test Participant categorical judgements of:

- color
- information content
- line texture
- size
- scales
- overall display

2.3.3.2 MOP 3b

Test participant subjective comments on the CAMPS display.

2.3.4 Objective 4

2.3.4.1 MDP 4a

Test participant ranking of the current kneeboard card and proposed alternative kneeboard cards.

2.3.4.2 MDP 4b

Test participant subjective comments on the format and content of the kneeboard cards.

2.3.5 Objective 5 (MDP 5)

Test participants categorical judgements of overall ease of planning with the CAMPS.

2.3.6 Objective 6 (MDP 6)

2.3.7 Objective 7 (MDP 7)

Test participant categorical judgements of the CAMPS/EPASS system.

2.3.8 Objective 8 (MDP 8)

Test participant comments on the aspects of the systems that they liked and disliked.

2.4 SCENARIO

The sensitivity of the experiment to the enemy threat was identified early. Too weak of a threat would allow anyone using manual or CAMPS procedures to maneuver unscathed. Too heavy of a threat would allow no one to survive no matter how well the mission was planned. So, selection of a threat became a critical issue. It was decided that the scenario and threat developed for the final exercise at the Weapons Training Instructor (WTI) Course held at Marine Aircraft Wing Training Squadron-1 (MAWTS-1), Yuma, Arizona, would be used. A detailed summary of the scenario and threat is contained in Appendix B.

2.5 TEST PARTICIPANTS

The 24 test participants for the CAMPS Test 1-82 were drawn from Marine Aircraft Group-13 at Marine Corps Air Station, El Toro, California. Requirements for participation were that the individual be a fixed-wing aviator or a naval flight officer, currently assigned to flight status, with experience in planning tactical missions desired. There were no rank limitations imposed statistics for the population of test participants used for the test which are given in Table 2-2.

Table 2-2. Test Participant Profile Statistics

	Major	Capt	1stLt
Number	4	12	8
Pilots	3	10	6
BNs	1	2	2
Years Service			
Mean	14.7	6.4	5.3
Std. Dev	3.0	1.7	1.8

SECTION 3

TEST ADMINISTRATION

3.1 ORGANIZATION

The administration of the CAMPS Test 1-82 was organized into four phases: Testing, Evaluation, Data Reduction, and Analysis. Figure 3-1 depicts these phases, their functions, and the inputs/outputs of each.

3.2 SCHEDULE

3.2.1 Testing Phase

CAMPS Test 1-82 was conducted during the week of 12-16 April 1982. Each day of testing was divided into three periods, scheduled as follows:

Period	
I	0730-1130
II	1030-1430
III	1330-1730

Each period consisted of four hours of activity broken down in the following manner:

Activity	Minute
Introductory Remarks	0-20
Mission Brief	21-30
Planning Period 1	31-90
Planning Period 2	91-150
Demonstration	151-180
Debrief	181-240

An outline of each activity is contained in Appendix C.

There was a one-hour overlap in scheduling between Periods I and II, and Periods II and III. This overlap allowed a more effective use of the CAMPS equipment and thus more observations in a shorter time frame.

Testing began with Period II on Monday and concluded with Period I on Friday. Table 3-1 contains a detailed schedule of test participant assignment to the test periods.

Table 3-1. Participant Schedule

MON		TUES			WED			THURS			FRI
II	III	I	II	III	I	II	III*	I	II	III	I
1	3	5	7	9	11	13	15	17	19	21	23
2	4	6	8	10	12	14	16	18	20	22	24

* Due to VIP demonstration, participants during this period did not do flight planning, however, they did respond to questionnaires.

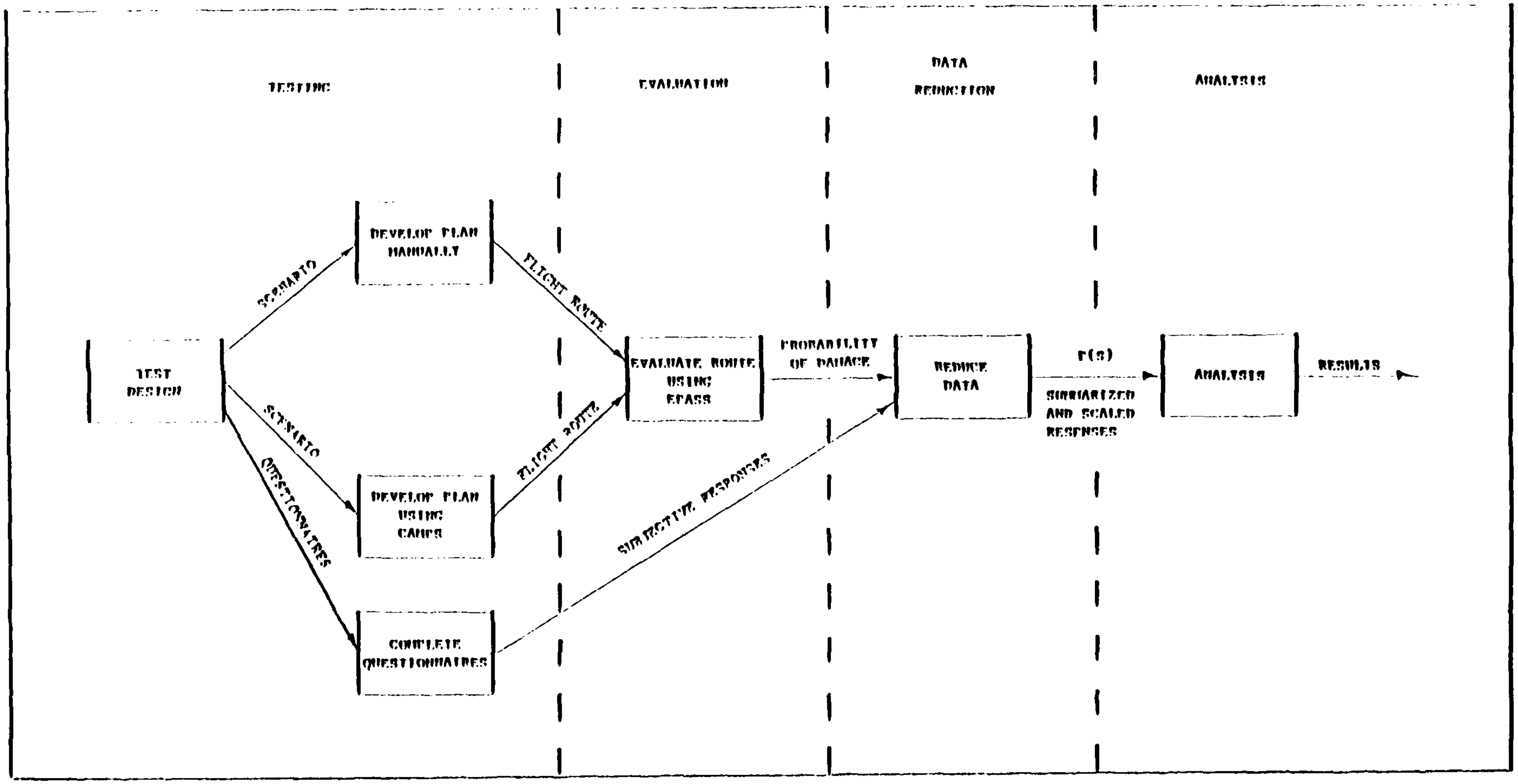


Figure 3-1. CAMPS Test 1-82 Organization

3.2.2 Evaluation Phase

The flight routes resulting from testing were evaluated on 30 April and 3 May 1982 at COMARCO, Inc., Anaheim, California.

3.2.3 Reduction and Analysis Phases

Data from the CAMPS Test was reduced and analyzed during the period 10-18 May 1982.

3.3 PERSONNEL REQUIREMENTS

Personnel required for the CAMPS Test were all Marine Officers provided from the Command Systems and Analysis Sections of MCTSSA, except where noted below.

Personnel requirements were as follows:

a.	Test Design and Preparation	3
b.	Test Supervision and Data Management	2
c.	Test Participants (MAG-13 El Toro)	24
d.	Data Evaluation and Analysis	2

3.4 MATERIAL REQUIREMENTS

3.4.1 Testing Phase

3.4.1.1 Facilities

The following spaces were provided by MAG-13 for the test:

Testing Office
Briefing Room
CAMPS Planning Room
Manual Planning Room

3.4.1.2 Hardware

The hardware used for the test was the Convergent Technology suite of equipment being used for the CAMPS. Figure 3-2 shows the hardware used for the test.

3.4.1.3 Software

The software for the test was Version 4.2 of CAMPS as provided by COMARCO, Inc.

3.4.1.4 Data Base

There were three data bases used for the CAMPS Test 1-82.

a. Terrain Elevation. This data base was provided by Defense Mapping Agency (DMA) except for a small segment digitized by NCTSSA personnel. It provided digitized elevation information for use in terrain masking computations.

b. Threat Parameter. The Threat Parameter data base is an ad hoc, unclassified data base of air defense weapon system parameters developed by COMARCO. To remain unclassified the parameters are set to provide a measure of weapons capabilities relative to the other weapon systems. Appendix D contains the parameters and their values for the various air defense weapons currently in the CAMPS.

c. Aircraft Performance. This data base was used to compute the performance of the aircraft during its mission. The aircraft used was the A-7 and the data contained in the data base was derived from the NATOPS manuals for that aircraft.

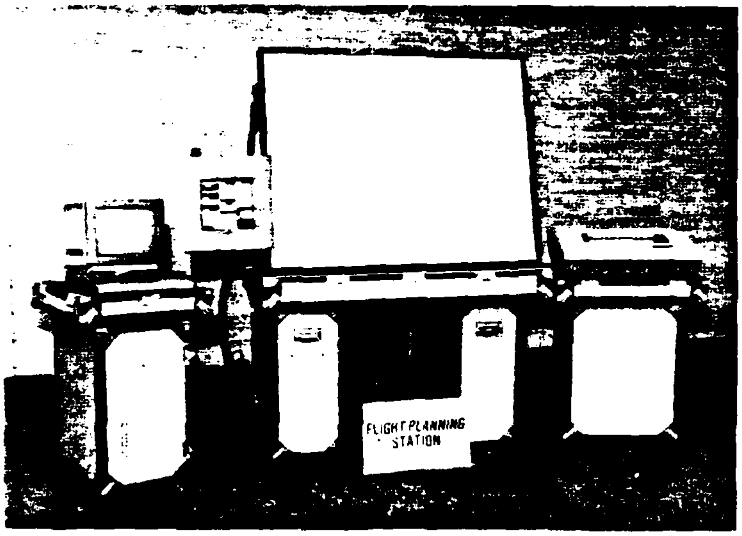


Figure 3-2. CAMPS Suite of Equipment

3.5 TRAINING

3.5.1 Testing Phase

3.5.1.1 Test Supervision and Data Management Personnel

Test supervisory and data management personnel received one day of hands-on training with the CAMPS at COMARCO, Inc. This training was conducted the week prior to the test. In addition, a representative of COMARCO, Inc., was present during testing to provide assistance as required.

3.5.1.2 Test Participants

Each test participant was given a brief demonstration of the basic capabilities of the CAMPS during the introductory remarks. They then received a detailed explanation and hands-on session for those functions specifically required for the CAMPS planning period. Lastly, a detailed brief and demonstration of all the CAMPS capabilities as well as selected EPASS functions was presented to each pair of test participants.

3.5.2 Evaluation Phase

In order to evaluate the flight routes developed during testing, two MCTSSA officers received approximately eight hours of training and hands-on experience in using the EPASS at COMARCO, Inc.

SECTION 4

DATA MANAGEMENT

4.1 DATA SOURCES

Data was collected for evaluation and analysis in support of the test objectives. Data was collected from the test participants by a combination of flight route summary sheets, written responses to questionnaires, and oral comments.

4.2 OBJECTIVE 1

4.2.1 MOP 1a

4.2.1.1 Data Collection

The raw data for this MOP was collected using the kneeboard card produced by the CAMPS and by a Manual Flight Route form. Copies of both are contained in Appendix E.

4.2.1.2 Data Evaluation

All flight routes developed during the testing phase were then entered into the EPASS terminal and evaluated against the threat devised for the scenario. For each route, the EPASS simulated engagements by enemy air defenses along the route. For each engagement, the enemy site firing, the time of the engagement and the probability of sustaining abort level damage, P(d), were then recorded on a Route Evaluation Data Collection and Reduction Form (Appendix E). In addition, the time-on-target (TOT) was noted and recorded.

4.2.1.3 Data Reduction

For each engagement along a route planned by a participant (there may have been none), the probability of survival, P(s), for that engagement, was computed as

$$P(s) = 1-P(d)$$

using the P(d) for the engagement. The resulting P(s) for each engagement was then recorded in column 5 of the Route Evaluation Data Collection Form. Finally, the probability of surviving to the target, $P_t(s)$, was computed by multiplying together the P(s) for all engagements with an engagement time equal to or earlier than the TOT. This $P_t(s)$ was then recorded at the bottom of the collection form. At the end of the evaluation phase, the $P_t(s)$'s of all participants were consolidated on the Objective 1 (MOP 1a) Data Summary Sheet and used as data for the analysis phase of Objective 1.

4.2.2 MOP 1b

The data management for MOP 1b was the same as for MOP 1a except the P(s) for all engagements were multiplied together to get a P(s) for the mission, $P_m(s)$.

4.3 OBJECTIVE 2

4.3.1 MOP 2a

4.3.1.1 Data Collection

The data for this MOP consisted of the number of slices circled on the Altitude Slice Questionnaire (Appendix E) as being the minimum number of slices required to do mission planning effectively.

4.3.1.2 Data Reduction

For each test participant, a tally consisting of his circled participant number (e.g., 5) was entered on the Data Summary Sheet (Appendix E) for the number of altitude slices indicated. Finally, the total number of tallies for each number of slices was recorded.

4.3.2 MOP 2b

4.3.2.1 Data Collection

Data collection for MOP 2b consisted of the listing, by the test participant, of those altitudes he would choose if a specified number of altitude slices were available to him. These altitudes were listed for an availability of 3 through 10 altitude slices on the Altitude Slice Questionnaire (Appendix E).

4.3.2.2 Relative Worth

The relative worth measure (w), as defined for this test, is based on the premise that selection of an item, when the number of possible selections is small, implies that a higher value is placed on that item than selection in the case where a greater number of selections is possible. For example, if you only get three wishes, then each wish chosen would presumably have a greater value to you than if you had ten or twenty wishes available.

To compute the relative worth measure, we have a number of different possible levels of selections available and a list of items to fill the selections at each level. This allows us to then assign a series of weights to each item based on the different selection levels it was assigned to. These weights consist of the inverse of the selection level for each assignment of an item. If an item is listed as one of three possible selections at level three, each item would get a weight of one-third assigned for that particular level.

As an example, let's assume there are four levels of selection available: 1, 2, 3, and 4. Each level is addressed separately and items A, B, C, and D are listed to fill the available selection slots at each level. One possible allocation looks like this:

1	2	3	4
C	C	C	C
	A	D	A
		A	B
			D

The relative worth, w, for each item would be computed as follows:

$$w_A = .50 + .33 + .25 = 1.08$$
$$w_B = .25 = .25$$
$$w_C = 1.0 + .50 + .33 + .25 = 2.08$$
$$w_D = .33 + .25 = .58$$

As can be seen, the weight for an item increases as its selection under diminished resources increases.

4.3.2.3 Data Reduction

Using the Objective 2 (MOP 2b) Data Reduction Form contained in Appendix E, a relative worth was computed for each altitude listed by a test participant. These values were then consolidated and grouped around index altitudes as follows:

Listed Altitudes	Index Altitudes
0-149	100
150-249	200
250-349	300
350-449	400
450-749	500
750-1,249	1,000
1,250-1,749	1,500
1,750-2,499	2,000
2,500-3,499	3,000
3,500-4,499	4,000
4,500-7,499	5,000
7,500-12,499	10,000
12,500 or more	15,000.

To arrive at a total relative worth, W, for an altitude, the highest individual relative worth value in the grouping range for an altitude was recorded on the Objective 2 (MOP 2b) Data Consolidation Form (Appendix E) and summed over all participants. This total relative worth, W, was then used to rank the altitudes during analysis.

4.4 OBJECTIVE 3

4.4.1 MOP 3a

4.4.1.1 Data Collection

Data collection for this MOP was conducted using the categorical judgments on the CAMPS Display Evaluation form contained in Appendix E.

4.4.1.2 Data Reduction

The data reduction for this MOP consisted of recording test participant responses on the Objective 3 (MOP 3a) Data Summary Sheet using a tally consisting of his circled participant number (e.g., ( )).

4.4.2 MOP 3b

4.4.2.1 Data Collection

Data collection for this MOP consisted of the participants written subjective comments on the CAMPS display made on the CAMPS Display Evaluation form (Appendix E).

4.4.2.2 Data Reduction

Reduction of the data for MOP 3b consisted of consolidation of the test participant comments.

4.5 OBJECTIVE 4

4.5.1 MOP 4a

4.5.1.1 Data Collection

Data collection for this MOP consisted of the four alternative kneeboard cards (Appendix E) ranked in order of preference by each test participant.

4.5.1.2 Data Reduction

The Data for MOP 4a was reduced by recording, for each participant, the ranking assigned to the kneeboard card alternatives. The Data Reduction Sheet for Objective 4 (MOP 4a) was used for this purpose and can be found in Appendix E.

4.5.2 MOP 4b

4.5.2.1 Data Collection

Data collection for MOP 4b consisted of the written comments of the test participants concerning the format and content of the kneeboard card alternatives provided to them. These comments were made on the kneeboard cards themselves.

4.5.2.2 Data Reduction

Data reduction for this MOP was limited to the consolidation of the test participant comments.

4.6 OBJECTIVE 5 (MOP 5)

4.6.1 Data Collection

Data collection for this MOP consisted of the categorical judgments of the test participants as indicated on the Ease of Planning Questionnaire contained in Appendix E.

4.6.2 Data Reduction

The data reduction for MOP 5 consisted of the recording of test participant responses on the Objective 5 (MOP 5) Data Summary Sheet using a tally of the circled participant number.

4.7 OBJECTIVE 6 (MOP 6)

4.7.1 Data Collection

Data collection for this objective was accomplished using the CAMPS EPASS Comparison form contained in Appendix E. Participants were asked to divide 100 points between each pair of system configurations listed on the form based on the value of the system to the mission planning process. For example, if you were comparing systems A and B, and considered them of equal value, then they would each be assigned 50 points. If B was considered extremely valuable and A of little or no value in comparison, then they would be marked as follows:

A __0__ B __100__.

4.7.2 Data Reduction

The data for this MOP was recorded on the Objective 6 (MOP 6) Data Reduction Form contained in Appendix E. This data was then reduced by using the Constant Sum Method of scaling. Details of the Constant Sum method are contained in Appendix F.

4.8 OBJECTIVE 7 (MOP 7)

4.8.1 Data Collection

Data Collection for Objective 7 consisted of the categorical judgment of the test participants as indicated on the General Evaluation form contained in Appendix E.

4.8.2 Data Reduction

The data reduction for MOP 7 consisted of recording the test participant responses on the Data Summary Sheet for Objective 7 (MOP 7) using a tally of the circled participant number.

4.9 OBJECTIVE 8 (MOP 8)

4.9.1 Data Collection

Data collection for MOP 8 consisted of the written comments of the test participants concerning their likes and dislikes about the CAMPS/EPASS. These comments were made on the General Evaluation form contained in Appendix E.

4.9.2 Data Reduction

Data reduction for this objective consisted of the consolidation of test participant comments under the liked and disliked categories.

4.10 DATA SUMMARIES

Summaries of the reduced data for each MOP are contained in Appendix G.

SECTION 5

DATA ANALYSIS

5.1 OBJECTIVE 1

The MOPs for Objective 1, as specified in paragraph 2.3.1, were analyzed using the same method of analysis.

5.1.1 Method of Analysis

Since each test participant developed flight plans using CAMPS and manual methods, the resulting probabilities of survival, P(S), could be organized into matched-pairs of data for each test participant. This made the data ideally suited to analysis by the Wilcoxon Matched-Pairs Signed-Ranks Test (see Siegel, "Nonparametric Statistics," McGraw-Hill 1956).

The Wilcoxon Signed-Ranks Test focuses on the difference between the data elements of each matched-pair. It considers the magnitude of the difference as well as the direction, thus giving more weight to data pairs which exhibit larger differences than to those exhibiting smaller differences. Details of the method can be found in Appendix H.

5.1.2 Assumptions

The Wilcoxon Matched-Pairs Signed-Ranks Test is a nonparametric technique and thus attributes no specific distribution to the data. The assumptions for the Signed-Ranks Test are that the differences being analyzed form a random sample from a distribution which is continuous and symmetric.

5.1.3 Hypotheses

The null hypothesis for each MOP of this objective is:

CAMPS planning is not more

effective than manual planning.

The corresponding alternative hypothesis is:

CAMPS planning is more effective

than manual planning.

5.1.4 Interpretation of Results

After the Signed-Ranks Test was applied to MOP 1a and MOP 1b, a p-value for each null hypothesis resulted. A p-value, or significance level, is a statement of the probability that, if the null hypothesis is rejected, you are in fact rejecting the true case.

Since null hypotheses are formulated for rejection and thus the implicit

acceptance of the alternative hypotheses, it is desired to reject the null hypothesis.

It is common that a null hypothesis is not rejected unless the p-value for the hypothesis is less than some probability prescribed as acceptable risk of rejecting a true case. This level of risk is denoted as < > and typically has values of .05 or .1.

5.2 OBJECTIVE 2

5.2.1 MOP 2a

The opinions of the test participants regarding the minimum number of altitude slices required were analyzed using the mode of the data to select the number of slices most preferred. In addition, the arithmetic mean and standard deviation for the data were computed.

5.2.2 MOP 2b

The analysis of the relative worth measure for this MOP consisted of ranking the altitudes by relative worth from highest to lowest.

5.3 OBJECTIVE 3

5.3.1 MOP 3a

Analysis of the categorical judgments for this MOP consisted of computing the percentage of test participants judging a display characteristic in each category.

5.3.2 MOP 3b

The comments of the test participants were summarized and are included without further analysis.

5.4 OBJECTIVE 4

5.4.1 MOP 4a

5.4.1.1 Method of Analysis

Although subjective in nature, the rankings of the kneeboard cards by the test participants for MOP 4a, were analyzed by constructing an interval scale based on the ordinal rankings of the four alternative kneeboard cards (Glenn F. Lindsay, "On Constructing Interval Scales from Ordinal Judgments", Naval Postgraduate School, 1977, unpublished).

As a check on the agreement of the rankings by the test participants, the Kendall coefficient of concordance was calculated. It indicates whether the judges applied essentially the same standard in ranking the various alternatives.

Details of these methods are contained in Appendix H.

5.4.1.2 Assumptions

The assumptions made to construct an interval scale from ordinal judgments are:

a. A judge cannot directly express his feelings about the scale value of an alternative, but is able to rank the alternatives in accordance with his feelings.

b. The feelings of the population of judges are a normally distributed random variable.

c. The variance in the feelings of the judges is the same for all alternatives.

d. The correlation coefficient for feelings between any pair of alternatives is the same.

In order to compute Kendall's coefficient of concordance, the only assumption required is the independence between rankings.

5.4.1.3 Interpretation of Results

The interpretation that can be made of an interval scale is best explained by an example. If four instances of some property being measured are denoted by the letters E, F, G, and H (for this MOP the property being measured is "user compatibility" and the instances are the four kneeboard card alternatives) then an interval measurement of the degree of the property possessed by the instances might be represented as follows:

```
- - - ! - - ! - - - - - - - - - - - - - - - - - - - - - ! - - ! - - - -
      F     G                                            H     E
```

On such a scale, the base or zero point as well as the units of measure are entirely arbitrary. It could be concluded that E and H possess more of the property than G and F, that there appears to be little difference between E and H as compared with the difference between E and F, etc. If the intervals between all instances were approximately equal, then very little information is provided. In such a case, since the units are arbitrary, the intervals could represent large but equal differences or small but equal differences.

A high or significant Kendall coefficient of concordance may be interpreted as meaning that the test participants applied essentially the same standard in ranking the kneeboard card alternatives. Though this does not assure that the ranking is correct (it may be influenced by external factors), it does give confidence in the ranking under the conditions of the test.

5.4.2 MOP 4b

The comments of the test participants regarding the kneeboard card were summarized and are included without further analysis.

5.5 OBJECTIVE 5

The method of analyzing the categorical judgments of the ease of planning of the CAMPS was to compute the percentage of test participants judging a characteristic in each category.

5.6 OBJECTIVE 6

The scaled ranking of the different systems resulting from data reduction was used without further analysis.

5.7 OBJECTIVE 7

The categorical judgment of the test participants as to their overall opinion of the CAMPS/EPASS were analyzed by computing the percentage of participants judging the system to be in each category.

5.8 OBJECTIVE 8

The comments of the participants regarding their likes and dislikes about the system were summarized and are discussed in Section 6, Results.

SECTION 6

RESULTS

6.1 OBJECTIVE 1

> To investigate whether a plan for a tactical air strike mission developed using CAMPS results in a higher probability of survival than one developed manually.

In order to meet Objective 1, the difference in the probabilities of survival for a mission planned with CAMPS and a manual mission was used to test the hypothesis that CAMPS planning is not more effective than manual planning. The hypothesis was tested for two parts of the mission: to the target and for the entire mission.

6.1.1 Results

From the analysis for Objective 1, it was possible to reject the hypothesis that CAMPS planning is not more effective than manual planning with the following levels of significance:

To the target	$p = .032$
Total Mission	$p = .052$

6.1.2 Discussion

The hypotheses for Objective 1 were designed to test for a difference between CAMPS and manual systems of planning. The results above tell us that there is a statistically significant difference between CAMPS and manual planning methods. That is, CAMPS planning provides a better probability of survival than manual planning. The hypotheses do not tell us, however, how much better.

We can get some insight into the magnitude of the difference by looking at the means of the probabilities of survival for each method. Table 6-1 contains the mean values and differences of the P(s) for the conditions of the test. If we consider the differences as improvement and compare them to their respective manual P(s), we get a percentage of improvement for both measures of performance:

to the target, 26%
and for the mission 24%

The probabilities of survival and their differences shown in Table 6-1 can be viewed from a different perspective. For example, if 100 aircraft were to fly missions planned manually and 100 aircraft were to fly missions planned with the CAMPS, the values in Table 6-1 tell us that it could be expected that 19 more aircraft would make it to the target and 16 more aircraft would return from the mission when using the CAMPS than when planning is done manually.

Table 6-1. Mean Probabilities of Survival

	CAMPS	Manual	Difference
To Target	.922	.734	.188
Mission	.824	.661	.163

6.2 OBJECTIVE 2

> To assess test participant attitudes regarding the number of required altitude slices and the specific altitudes preferred.

For this objective, test participant opinions were used to assess the number of altitudes required and the relative worth of various altitudes.

6.2.1 Results

Table 6-2 contains the percentage of test participants selecting the various altitude slice availabilities. Statistics for this data are:

Mode = 5
Arithmetic Mean = 5.89
Standard Deviation = 1.66

Table 6-3 contains the index altitudes ranked according to their relative worth as computed during data reduction.

Table 6-2. Minimum Number of Altitude Slices Required

Number of Slices	Percent Selecting
3	0
4	16
5	37
6	21
7	10
8	5
9	5
10	5

Table 6-3. Ranking of Altitudes by Relative Worth

Ranking	Index Altitude	Relative Worth
1	500	31.834
2	1,000	29.073
3	100	25.365
4	200	21.856
5	300	10.412
6	5,000	9.434
7	10,000	9.189
8	1,500	5.989
9	15,000	5.572
10	3,000	4.779
11	2,000	4.129
12	400	4.04
13	4,000	.858

6.2.2 Discussion

The results obtained for the minimum number of altitude slices tell us that at least 4 are required and probably no more than 7 would be necessary.

As to what these 4 to 7 altitudes might be, we look to a plot of the relative worths of the altitudes by rank (Figure 6-1). This plot reveals two clusters of the data. This would indicate that the 4 highest ranking altitudes

500
1,000
100
200

might be selected with some confidence over those of the lower group. the ranking of altitudes within a cluster, especially the lower one, should be considered more variable and subject to interpretation.

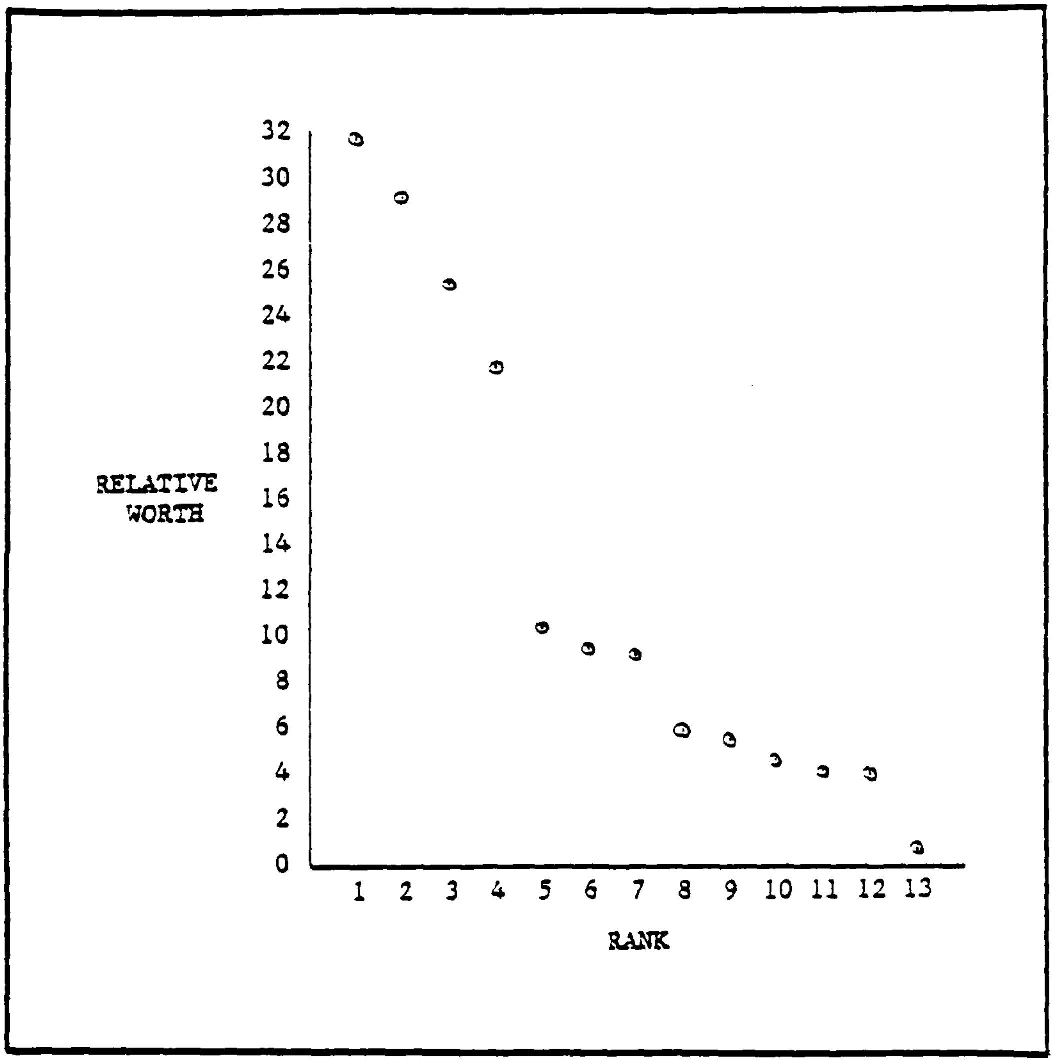


Figure 6-1. Plot of Relative Worth of Index Altitudes by Rank

6.3 OBJECTIVE 3

To assess test participant attitudes regarding the physical appearance and information content of the CAMPS display.

6.3.1 Results

The results for this objective are summmarized in Table 6-4 and in Appendix G [Test Participant Comments - Objective 3 (MOP 3b)].

Table 6-4. CAMPS Display Categorical Judgments
(% responding)

Property	Poor	Only Fair	Good	Excellent
Color		8	50	42
Information Content		4	38	58
Line Textures		13	58	29
Screen Size	4	21	67	8
Map Scales		4	58	38
Overall			60	40

6.3.2 Discussion

Key aspects of the CAMPS display that several test participants wanted changed were:

1) screen size (wanted it larger),

2) ability to change altitude display during planning of a mission,

3) computer response too slow.

Other comments are provided in Appendix G without further discussion.

6.4 OBJECTIVE 4

To assess the user compatibility of the current CAMPS kneeboard card.

6.4.1 Results

The analysis of the rankings of the kneeboard card alternatives resulted in the following scale values:

Alternative	Scale Value
A	-.982
B	.094
C	.436
D	.452

Kendall's Coefficient of Concordance resulted in the rejection at the .01 level of the hypothesis that the judges used different criterion to rank the kneeboard card alternatives.

Comments on the various characteristics of the cards are contained in Appendix G [Test Participant Comments - Objective 4 (MOP 4b)].

6.4.2 Discussion

Arranging the alternatives on a scale in accordance with their resultant scale value, it can be seen that there seems to be little difference between alternatives C and D and that alternative A, the current kneeboard card, is least preferred of all.

6.5 OBJECTIVE 5

To assess the ease of planning with CAMPS.

In order to accomplish this objective, the test participants were asked to rate the CAMPS in four areas of planning and then rate it overall. The five statements are shown in Figure 6-2.

1. Rate how easy it was for you to get information you needed from the system.
2. Rate how easy it was for you to use the information provided by the system to plan your mission.
3. Rate how easy to understaand and execute, were the procedures for using the system.
4. Rate how well the system provided the level of detail of information you required.
5. Considering your responses to the above, rate the overall ease of planning a tacitcal air strike flight plan with the CAMPS.

Figure 6-2. Ease of Planning Categorical Judgment Statements

The results for this objective, the percentage of test participants responding to the five statements in each category, are shown in Table 6-5 by statement number.

Table 6-5. Ease of Planning Categorical Judgment Results (%)

	Only Fair	Good	Excellent
1	8	38	54
2	4	25	71
3		58	42
4	4	42	54
Overall		38	62

6.6 OBJECTIVE 6

> To assess the marginal value of adding Experimental Penetration and Analysis Support System (EPASS) type capabilities to the CAMPS.

This objective was met by having the test participants compare the various systems (i.e., CAMPS, CAMPS/EPASS, EPASS) to each other in regard to their value to the mission planning process.

6.6.1 Results

The results for this objective were the scale values shown below for each of the systems.

CAMPS/EPASS	2.16
CAMPS	1.05
EPASS	.44

6.6.2 Discussion

What the results above tell us is that, in the opinion of the test participants, CAMPS has twice the value of EPASS in mission planning but that CAMPS with EPASS would have twice the value of CAMPS alone. Thus the marginal value of adding EPASS to CAMPS is as great as the value of CAMPS alone.

6.7 OBJECTIVE 7

> To assess the user's overall opinion of the CAMPS/EPASS system as a mission planning tool.

In order to achieve this objective, test participants were asked to respond to the following:

> What was your overall impression of a CAMPS/EPASS type of system as a tool for mission planning?
>
> Poor (unimpressed) _______
> Fair _______
> Good _______
> Excellent (very impressed) _______

The results of the responses were that 7[illegible]% of the test participants were very impressed while 100% rated the system good or better.

6.8 OBJECTIVE 8

To compile a list of participant likes and dislikes about the CAMPS/EPASS.

The comments of the test participants for this objective are provided in Appendix G (Test participant Comments - Objective 8) without discussion here.

SECTION 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

7.1.1 Effectiveness

Based on the results of this test and the previous test that used CAMPS, the conclusion can be drawn that the CAMPS is a valuable mission planning aid. It should be pointed out however, that the results of both of these tests depended upon the level of threat and the perfect intelligence assumptions. The fact that many participants achieved probabilities of survival of 1 with both methods of planning also reduced our ability to discriminate between the systems with accuracy. These limitations do not lessen confidence in the results but reduce the ability to generalize the results to other threat and intelligence reliability levels.

The value of an automated system would vary as the threat varies. That is, when there is little or no threat, there would be little or no difference in missions planned with either system. As the intensity of the threat increases, it would be expected that the value of the CAMPS would increase until a point is reached where the threat is so dense that missions planned with perfect knowledge, whatever its source, would be flown at extremely high risk.

The sensitivity of the effectiveness of the CAMPS to changes in the level of threat and intelligence reliability is unknown. This does not diminish the potential value of the CAMPS to the mission planner, but only our ability to predict its effectiveness.

7.1.2 Utility

On the whole, the vast majority of the test participants felt the CAMPS would be invaluable to them. They felt that it provided them with tools not currently available to them and that these tools were easy to use and apply.

Their indications of deficiencies and suggestions for improvements are detailed in Section 6 (RESULTS) and in Appendix G. From these, it can be concluded that the CAMPS is on the right track. It provides a needed capability to the mission planner and is easy to use.

7.2 RECOMMENDATIONS

As with most tests or experiments, more questions result than are answered. The CAMPS Test 1-82 is no exception.

The key questions to be answered in the future are:

1. What is the sensitivity of CAMPS performance to different levels of enemy threat?

2. How will real intelligence (i.e., reliabilities less than 100%) affect the performance and utility of the CAMPS.

It is recommended that tasking and funding be provided to investigate the above questions. In addition, data should continue to be collected to further the evaluation of the effectiveness of JAMPS and its utility. This will ensure that specifications for a final fielded system, if any, provide the best possible tool to the Marine aviator.

APPENDIX A

FLIGHT ROUTE EVALUATION PROCEDURES

A.1 INTRODUCTION

In order to compare the flight routes prepared by participants using CAMPS and manual planning methods, the routes were entered into a COMARCO, Inc., system called EPASS (Experimental Penetration Analysis Support System). The EPASS simulates the flying of a mission through a specified threat over specified terrain. Among its outputs is a probability that a particular engagement of a surface-to-air missile (SAM) will inflict abort-level damage to the aircraft flying the mission. The next paragraph outlines the procedures used to evaluate the flight routes using the EPASS.

A.2 EVALUATION PROCEDURE

A. Log-on to COMARCO, Inc. EPASS Program

B. Designate for scenario

1. Terrain
2. Air Defenses
3. Aircraft

C. For each flight route

1. Set up a Data Collection and Reduction Form
   a. Filling in Participant Number
   b. Circle method of planning.

2. Enter all turnpoints/checkpoints of route in sequence by entering:

   a. Coordinates
   b. Altitude
   c. Speed

3. Evaluate route by using EPASS simulation.

4. Display engagement list.

5. Record following data on Collection and Reduction Form.

   a. Sites firing (column 2)
   b. Time of engagement (column 3)
   c. Probability of damage, P(d) for each firing (column 5)*
   d. Time on target (TOT)

* NOTE: Column 4 of the Data Collection and Reduction Form is not used.

APPENDIX B

SCENARIO

B.1 INTRODUCTION

The scenario for the CAMPS Test 1-82 was very limited but specifically designed to provide an environment and situation to test the particular CAMPS capabilities in question.

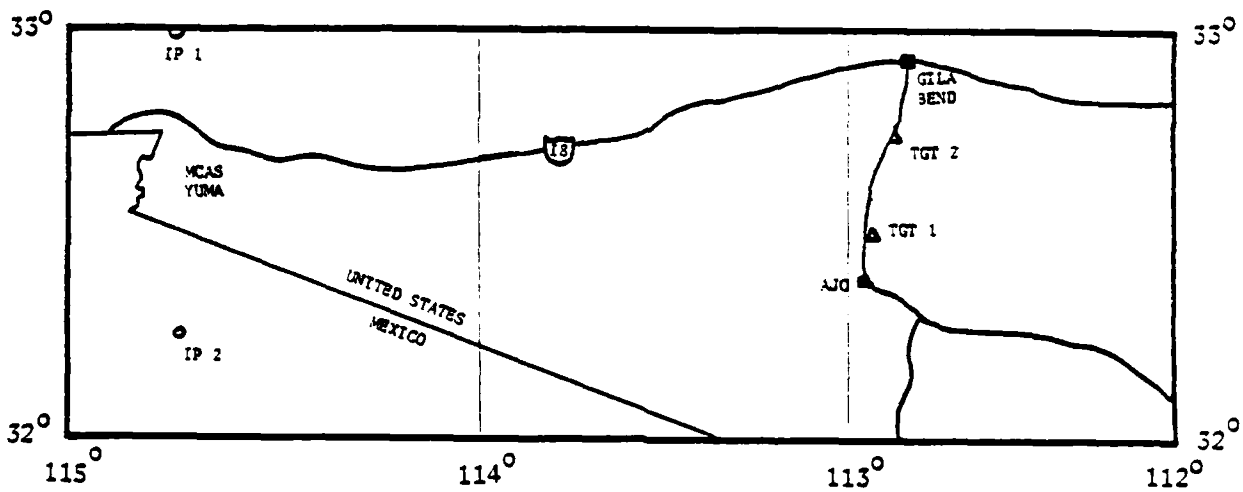
Participants were not asked to develop complete flight plans in that they had no fuel or time calculations to consider. They only had to develop the route itself. In order to structure the test environment, the planning constraints described below were developed.

B.2 DESCRIPTION

The situation used for this test was based on a scenario used at the WTI course held at MAWTS-1, Yuma, Arizona.

B.2.1 Planning Region

The region made available to the participants for planning is shown below:



B.2.2 Missions

There were two missions planned by each participant. Each mission consisted of a designated start point and a target. The participant was "placed" in the air at the start point and required to develop a route to the target and back to the start point. The two missions are described below:

MISSION #1

START POINT: $33^{\circ}00'$ N 10,000 FT MSL
$114^{\circ}45'$ W

TARGET: $32^{\circ}31'30''$ N
$112^{\circ}55'45''$ W

MISSION #2

START POINT: $32^{\circ}15'$ N 10,000 FT MSL
$114^{\circ}45'$ W

TARGET: $32^{\circ}43'$ N
$112^{\circ}51'$ W

3.2.3 Profile Constraints

In order to simulate the effects of fuel and range limitations that would normally apply to mission planning, participants were required to adhere to the certain mission profile constraints.

Altitudes and the distance that could be flown at an altitude were limited so that the entire mission could not be flown at any one altitude because of fuel limitations. The limitations on altitude, speed, and distance are shown below.

Altitude (ft)	Maximum Cumulative Distance at or below Altitude (NM)	Ground Speed (Kts)
10,000 MSL	300	420
1,000 AGL	150	480
500 AGL	60	480
100 AGL	30	540

For example, if 30 NM are flown at 100 ft AGL, then only 30 NM could be flown at 500 ft AGL.

Total Round Trip Distance for a route had to be 300 NM or less.

3.2.4 Threat

Enemy SAM sites used for the test were also based on the WTI Scenario. The type and location of the sites are listed below:

SURFACE-TO-AIR MISSILE THREAT

TYPE	LOCATION
SA3	32 39 00 N 112 36 00 W
SA4	32 24 18 N 112 49 40 W

SA4	32 55 35 N 112 42 35 W
SA4	32 50 00 N 112 43 00 W
SA6	32 07 27 N 112 45 48 W
SA6	32 16 11 N 112 44 11 W
SA6	32 14 32 N 112 56 41 W
SA6	32 40 00 N 112 34 00 W
SA6	32 50 00 N 113 14 00 W
SA6	32 36 20 N 113 06 00 W
SA8	32 49 06 N 112 54 41 W
SA8	32 41 02 N 112 37 36 W
SA8*	32 52 30 N 112 41 00 W
SA8*	32 24 30 N 113 00 00 W
SA9	32 39 00 N 112 35 59 W
SA9	32 35 30 N 113 05 30 W
SA9	32 36 24 N 113 05 12 W
ZSU 23/4	32 46 57 N 112 51 58 W
ZSU 23/4	32 48 24 N 112 52 32 W
ZSU 23/4	32 40 30 N 112 37 00 W

ZSU 23/4	32 39 00 N 112 36 00 W
ZSU 23/4	32 36 24 N 113 05 12 W
ZSU 23/4	32 35 30 N 113 05 30 W
S-60 (57mm)	32 39 59 N 112 36 59 W

* These sites were added to the sites listed in the WTI scenario.

APPENDIX C

TEST PERIOD OUTLINE

C.1 OUTLINE

I. Welcome Aboard & Introduction

A. INTRODUCTIONS

B. PURPOSES -- The purposes of this test are two-fold:

(1) To see if an automated system such as this will aid in the flight planning of tactical missions.

(2) To expose as many aviators as possible to the system and make them aware of the potential capabilities.

Right now, no aviators are involved in its acquisition. We want to find out if the aviation community has a need for a system like this and if so get them involved in its acquisition by generating a ground swell of opinion from the FMF and thus encouraging the designation of an aviation sponsor at HQMC.

C. BACKGROUND

What is CAMPS? (Show display slices)
Who developed it? Sterling Engineering Division COMARCO, Inc.
When we get USMC system & how many.

This system is on loan from COMARCO to the U.S. Navy who in turn has loaned it to the USMC for use at WTI 1-82 and for this test.

D. WHAT YOU'LL BE DOING

MISSION BRIEFING

FLIGHT ROUTE PLANNING

CAMPS

MANUAL

DEMONSTRATION (CAMPS/EPASS)

DEBRIEF

II. MISSION BRIEFING

Situation and Mission

General Orientation
Overall Mission

Enemy Threat (G-2)

Mission Parameters and Aircraft Type

Target Assignments

III. PLANNING

Period 1.

Period 2.

IV. CAMPS/EPASS DEMONSTRATION

V. DEBRIEF

Questionnaires
Comments

C.2 SCHEDULE

	TEST PERIOD		
	I	II	III
Welcome & Mission Brief	0730	1030	1330
Planning Period 1	0800	1100	1400
Planning Period 2	0900	1200	1500
Demonstration	1000	1300	1600
Debrief	1030	1330	1630
End	1130	1430	1730

APPENDIX D

THREAT PARAMETERS

	-SA-2B	-SA-2E	-SA-3	-SA-4	-NOT USED	-SA-6	-SA-7	-SA-8	-SA-9
1 THREAT NAME (8 CHAR)	SA2B	SA2E	SA3	SA4	NUSE	SA6	SA7	SA8	SA9
2 CPASS ABBRV THREAT NAME (4 CHAR)									
3 GUIDANCE: 1=RADAR 2=IR 3=RADAR GUN 4=OPTICAL GUN	1.000	1.000	1.000	1.000	1.000	1.000	2.000	1.000	2.000
4 RADAR BEAM TYPE: 1=TWS AZ/EL 2=TWS V-BM 3=PENCIL	1.000	1.000	2.000	3.000	3.000	3.000	0.000	3.000	0.000
5 RADAR BEAM WIDTH - WIDE (DEG) NOT USED W/ PENCIL	10.000	12.000	6.000	6.000	0.000	6.000	0.000	6.000	0.000
6 RADAR BEAM WIDTH - NARROW (DEG).	1.000	1.200	0.900	1.250	1.250	0.900	0.000	0.600	0.000
7 DISTRIBUTED THREAT ALLOWED? 0=NO 1=YES	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8 ANTENNA HEIGHT (FEET)	10.000	10.000	25.000	15.000	15.000	15.000	0.000	10.000	0.000
9 PINIT = INIT PK, ON FRONT, BEFORE OTHER EFFECTS	0.330	0.675	0.800	0.920	0.920	0.910	0.100	1.100	0.175
10 RIN = STATIC INNER BOUNDARY (NM.)	4.000	3.000	4.000	5.000	5.000	2.000	0.300	1.500	0.100
11 ROUT = STATIC OUTER BOUNDARY (NM.)	18.000	25.000	21.000	40.000	30.000	13.000	3.000	7.000	3.500
12 ZMAX/ZCRIT = MAX ALT.CRIT ALT (FEET.HUNDREDS FT)	90000.006	90000.005	60000.000	75000.102	60000.102	60000.000	6000.000	20000.000	15000.000
13 SPEEDM = MISSILE VELOCITY (KNOTS)	1250.000	1350.000	1260.000	1983.000	1983.000	1652.500	700.000	1260.000	925.000
14 PHIMIN = MIN TRACKING ELEVATION ANGLE (DEG.)	1.335	1.000	0.600	1.250	1.250	1.000	0.290	1.000	0.390
15 PHIMAX = MAX TRACKING ELEVATION ANGLE (DEG.)	60.000	60.000	79.945	85.000	80.000	85.000	181.000	83.000	101.000
16 C1 = KURTOSIS FACTOR: 1=PARABOLA >1=FLATTER	0.900	0.600	1.400	3.000	3.000	1.000	1.000	1.000	1.000
17 L = PD PEAK LOCATION (0-1.0): .6=.6 OUT RNG	0.600	0.150	0.750	0.750	0.750	0.600	0.750	0.500	0.750
18 R1 = LOW ELEV (ALT) DEGRADATION FACTOR	0.300	0.200	0.150	0.100	0.100	0.000	0.000	0.400	0.000
19 R2 = SLEW RATE FACTOR	0.001	0.005	0.005	0.005	0.005	0.001	0.003	0.001	0.001
20 R3 = BURST ANGLE FACTOR	0.650	0.300	0.010	0.100	0.100	0.250	0.400	0.300	0.350
21 R4 = SELF PROTECT ECM MULTIPLIER	0.616	0.120	0.360	0.400	0.400	0.000	0.000	0.600	0.000
22 R5 = ESCORT JAMMING ECM MULTIPLIER	0.010	0.100	0.606	0.650	0.650	0.300	0.000	0.000	0.000
23 R6 = CHAFF ECM MULTIPLIER	0.015	0.015	0.639	1.000	1.000	0.500	0.000	0.135	0.000
24 R7 = FRONT-SIDE/OVERHEAD-REAR SCALE FACTOR	0.600	0.306	0.500	0.350	0.350	0.225	-6.000	0.400	-4.250
25 R8 = FRONT-SIDE/OVERHEAD-REAR SLOPE FACTOR	3.900	2.500	1.100	1.000	1.000	0.000	0.000	0.100	0.500
26 RL = F-S-R LOC'N (0-180 DEG)0=FRONT 90=SIDE	52.000	52.000	115.000	70.600	70.000	70.000	90.000	70.000	90.000
27 R10 = STANDOFF JAMMING ECM MULTIPLIER	0.950	0.423	0.644	0.720	0.720	0.200	0.000	0.000	0.000

	-SA-10	-ZU23-2	-ZSU23-4H	-ZSU23-4U	-ZSU57-2	-S-60	-HAWK	-IHAWK	-RAPIER	-ROLAND 2	-CROTALE
1 THREAT NAME (8 CHAR)	SA10	Z232	Z34H	Z34U	57-2	S60	HAWK	IHWK	RAPR	ROLD	CROT
2 CPASS ABBRV THREAT NAME (4 CHAR)											
3 GUIDANCE: 1=RADAR 2=IR 3=RADAR GUN 4=OPTICAL GUN	1.000	4.000	3.000	4.000	4.000	3.000	1.000	1.000	1.000	1.000	1.000
4 RADAR BEAM TYPE: 1=TWS AZ/EL 2=TWS V-BM 3=PENCIL	3.000	0.000	3.000	0.000	0.000	3.000	3.000	3.000	3.000	3.000	3.000
5 RADAR BEAM WIDTH - WIDE (DEG) NOT USED W/ PENCIL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6 RADAR BEAM WIDTH - NARROW (DEG).	0.500	0.000	1.400	0.000	0.000	1.700	1.200	1.000	0.500	1.100	1.100
7 DISTRIBUTED THREAT ALLOWED? 0=NO 1=YES	0.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000
8 ANTENNA HEIGHT (FEET)	5.000	0.000	15.000	0.000	0.000	15.000	15.000	15.000	15.000	10.000	15.000
9 PINIT = INIT PK, ON FRONT, BEFORE OTHER EFFECTS	1.100	0.700	0.950	0.900	0.750	0.000	0.920	0.950	0.970	0.970	0.950
10 RIN = STATIC INNER BOUNDARY (NM.)	1.500	0.010	0.010	0.010	0.010	0.010	1.300	1.260	1.000	1.260	1.200
11 ROUT = STATIC OUTER BOUNDARY (NM.)	23.000	1.200	1.500	1.200	2.000	3.100	21.600	25.600	5.000	6.000	5.500
12 ZMAX/ZCRIT = MAX ALT.CRIT ALT (FEET.HUNDREDS FT)	15000.020	6000.600	4000.000	5000.600	6000.000	8000.600	35000.090	35000.090	10000.019	15000.019	10000.090
13 SPEEDM = MISSILE VELOCITY (KNOTS)	3600.000	9999.000	9999.000	9999.000	9999.000	9999.000	1652.500	1652.500	1652.500	1600.000	1600.000
14 PHIMIN = MIN TRACKING ELEVATION ANGLE (DEG.)	0.550	0.750	0.750	0.750	0.750	0.750	1.000	1.000	1.600	1.000	1.000
15 PHIMAX = MAX TRACKING ELEVATION ANGLE (DEG.)	101.000	90.000	87.000	87.000	87.000	87.000	85.000	85.000	85.000	85.000	85.000
16 C1 = KURTOSIS FACTOR: 1=PARABOLA >1=FLATTER	1.000	1.000	1.000	1.000	1.000	1.000	0.750	0.750	0.750	0.750	0.750
17 L = PD PEAK LOCATION (0-1.0): .6=.6 OUT RNG	0.500	0.750	0.300	0.750	0.300	0.300	0.660	0.660	0.500	0.500	0.500
18 R1 = LOW ELEV (ALT) DEGRADATION FACTOR	0.000	0.000	0.050	0.000	0.000	0.050	0.000	0.000	0.400	0.000	0.000
19 R2 = SLEW RATE FACTOR	0.001	0.001	0.001	0.001	0.003	0.002	0.005	0.005	0.005	0.005	0.005
20 R3 = BURST ANGLE FACTOR	0.115	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
21 R4 = SELF PROTECT ECM MULTIPLIER	0.000	0.000	0.000	0.000	0.000	0.500	0.100	0.100	0.000	0.100	0.100
22 R5 = ESCORT JAMMING ECM MULTIPLIER	0.000	0.000	0.000	0.000	0.000	0.300	0.300	0.300	0.000	0.300	0.300
23 R6 = CHAFF ECM MULTIPLIER	0.130	0.000	0.150	0.000	0.000	0.015	0.500	0.500	0.200	0.500	0.500
24 R7 = FRONT-SIDE/OVERHEAD-REAR SCALE FACTOR	0.325	0.400	0.400	0.400	0.400	0.400	0.350	0.350	0.350	0.350	0.350
25 R8 = FRONT-SIDE/OVERHEAD-REAR SLOPE FACTOR	0.015	0.400	0.400	0.400	0.400	0.400	1.000	1.000	1.000	1.000	1.000
26 RL = F-S-R LOC'N (0-180 DEG)0=FRONT 90=SIDE	140.000	115.000	115.000	115.000	115.000	115.000	70.000	70.000	70.000	70.000	70.000
27 R10 = STANDOFF JAMMING ECM MULTIPLIER	0.000	0.000	0.000	0.000	0.000	0.000	0.300	0.300	0.000	0.300	0.300

APPENDIX E

DATA COLLECTION AND REDUCTION FORMS

OBJECTIVE 6

OBJECTIVE 7

OBJECTIVE 8

CAMPS KNEEBOARD CARD

PILOT'S FLIGHT PLAN AND FLIGHT LOG

CLEARANCE　　　　　　TAKE-OFF,CLIMB,CRUISE DATA

FREQUENCIES

DEP FIELD DATA　　　　　　TOTAL DIST　TOTAL ETE　TOTAL FUEL

207.2　29+30　9.0

ROUTE FIX	IDENT FREQ	LAT LONG	MAG CRS	DIS,LG TGT	SPD	ETE,LG CUM	ETA	FUEL REM	ACTUAL FUEL
0		325957N 1144440W							
1 11.0KA		323146N 1142311W	103	19.9 137.3	420	02+30 02+50		.3 8.2	
2 1000 A		324608N 1134634W	039	31.4 105.9	420	05+57 08+47		.2 7.9	
3 1000 A		324112N 1131943W	091	23.2 132.7	420	03+19 12+06		.3 7.6	
4 500 A		324017N 1130540W	083	11.9 120.3	480	01+33 13+41		.2 7.4	
5 100 A		324040N 1125550W	075	3.3 112.8	540	00+39 14+40		.2 7.2	
6 100 A		323149N 1125333W	166	8.8 103.7	540	00+59 15+39		.2 7.0	
7 100 A		322313N 1130554W	215	12.2 91.4	540	01+22 17+00		.3 6.8	
8 500 A		323448N 1132651W	292	21.1 70.3	480	02+29 19+30		.4 6.4	
9 1000 A		324047N 1134516W	230	16.7 53.6	480	02+05 21+34		.3 6.1	
10 11.0KA		325959N 1144438W	231	53.6 .0	420	07+55 29+30		.3 5.4	

SCL:　3XNKS2MR/4.

ROUTE NAME: 9.9

MANUAL FLIGHT ROUTE FORM

PARTICIPANT # ______

PAGE_____OF_____

TARGET # ______

CHECKPOINT* NO.	LAT / LONG	ALTITUDE(FT) M=MSL A=AGL	SPEED (KTS)	LEG DISTANCE (NM)
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				

* INDICATE TGT, IP ETC. BENEATH THE CHECKPOINT NO.
INCLUDE TGT AS A CHECKPOINT

Route Evaluation Data Collection & Reduction Form

Participant No. ________

Manual CAMPS (circle one) Time on Target (TOT) ________

1	2	3	4	5	6
Engagement Number (i)	Firing Site	Time of Engagement (t_i)	$P_i(D)$ Potential	$P_i(D)$ Residual	$P_i(S) = 1 - (5)$
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

$$P_{tgt}(S) = \prod P_i(S) \quad \forall t_i \leq TOT = \_\_\_\_\_ = P_{tgt}(S)$$

$$P_{msn}(S) = \prod P_i(S) \quad \forall t_i = \_\_\_\_\_ = P_{msn}(S)$$

OBJECTIVE 1 (MOP 1a)

DATA SUMMARY SHEET

Participant Number	P(S) CAMPS	P(S) Manual	D_i $P_c(s) - P_m(s)$	RANK
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
N				
Statistic (T)				
MEANS				
STD. DEV.				

ALTITUDE SLICE QUESTIONNAIRE

PARTICIPANT # ______

CURRENT	3	4	5	6	7	8	9	10
100								
500								
1000								

PREFERRED ALTITUDES

OBJECTIVE 2 (MOD 2a)

DATA SUMMARY SHEET

No. of Slices	Talley for Selection As Minimum	Sum of Tallies
3		
4		
5		
6		
7		
8		
9		
10		

OBJECTIVE 2 (MOP 2b)

DATA REDUCTION FORM

Participant No. ______

1	2								3	4
ALTITUDES	3	4	5	6	7	8	9	10	DECIMAL VALUE	RELATIVE WORTH (W)
	128	64	32	16	8	4	2	1		

OBJECTIVE 2 (MOP 2b)

DATA CONSOLIDATION FORM

(1)	(2)																								(3)
ALTITUDES	RELATIVE WORTH BY TEST PARTICIPANT																								SUM
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	(S)

PARTICIPANT NO. ____________

CAMPS DISPLAY EVALUATION

Indicate your opinion as to the adequacy of the various elements of the CAMPS display by placing an "X" on the appropriate line.

Area	Terrible	Poor	Only Fair	Good	Excellent
Color	______	______	______	______	______
Information Content	______	______	______	______	______
Line Textures	______	______	______	______	______
Screen Size	______	______	______	______	______
Map Scales	______	______	______	______	______
Overall, how do you rate the CAMPS display?	______	______	______	______	______

Other comments about the display/map setup?

OBJECTIVE 3 (MOP 3a)
DATA SUMMARY SHEET

	POOR	ONLY FAIR	GOOD	EXCELLENT
COLOR				
INFO CONTENT				
LINE TEXTURES				
SCREEN SIZE				
MAP SCALES				
OVERALL				

A

KNEEBOARD CARDS

COMBAT MISSION FLIGHT PLAN 41 TOT:

IDENT	CHECKPOINT	ALT SAA	MAG CRS	DIST TO GO	GND SPD	ETE CUM	ETA ATA	FUEL REM	ACTUAL FUEL
0									
AAA 1	3600.02N								
137/120	12600.00E								
1				108				4.3	
AAA 1	3747.29N	15000M	106	75	300	21-30		11.0	
199/ 13	12556.55E			74		21-30			
2 SD				14				.3	
AAA 1	3757.05N	15000M	059	52	300	01-52		10.7	
120/ 6	12608.99E			74		23-22			
2				6				1.1	
AAA 1	3801.10N	500A	059	56	480	00-41		11.7	
92/ 14	12614.15E			74		24-03			
3				37				1.4	
AAA 1	3824.68N	500A	059	19	480	04-40		9.3	
65/ 36	12651.02E			74		23-43			
4 IP				14				3.5	
AAA 1	3838.72N	500A	310	4	480	01-48		3.3	
47/ 55	12641.17E			74		30-31			
5 TGT				5				.2	
AAA 1	3841.35N	230A	311	1	540	00-36		3.6	
42/ 45	12636.17E			74		31-03			
6				5				.2	
MAS 300	3845.68N	230A	349	154	540	00-36		3.4	
131/ 50	12632.27E			74		31-39			
7				7				.3	
MAS 300	3852.65N	500A	357	147	540	00-48		3.1	
129/ 39	12630.53E			74		32-26			
8				31				1.0	
MAS 300	3844.23N	500A	239	116	480	03-53		7.1	
166/ 29	12528.95E			74		36-20			
9				117				3.8	
AAA 1	3715.02N	500A	158	1	480	14-35		3.3	
146/ 32	12701.00E			74		50-55			

SCL: 10XMK 82SE 2XWG TANK 1XGUN AMMO 1XALQ119 2XAIM7

ROUTE NAME: 41

TOTAL DISTANCE: 345 TOTAL TIME: 50-55 TOTAL FUEL: 12.0

B

COMBAT MISSION FLIGHT PLAN W1 TGT:

NAV AID IDENT	CHECKPOINT	ALT MSL AGL	MAG CRS MVAR	DIST LEG TO GO	GND SPD	ETE CUM	ETA ATA	FUEL REM	ACTUAL FUEL
0 AAA 1 137/120	3600.00N 12600.00E								
1 AAA 1 199/ 13	3747.29N 12556.55E	15000M 14000A	006 7W	108 76	300	21+30 21+30		4.3 11.0	
2 GO AAA 1 120/ 5	3757.05N 12608.49E	15000M 14000A	159 7W	14 62	300	01+52 23+22		.3 10.7	
2 AAA 1 92/ 14	3801.10N 12614.13E	1500M 500A	159 7W	6 56	490	00+41 24+03		0.0 10.7	
3 AAA 1 65/ 36	3924.68N 12551.02E	1500M 500A	353 7W	37 19	490	04+40 28+43		1.4 9.3	
4 IP AAA 1 47/ 55	3838..2N 12641.17E	1500M 500A	311 7W	14 4	490	01+48 30+31		0.5 8.8	
5 TGT AAA 1 42/ 45	3841.35N 12636.17E	1200M 200A	311 7W	5 0	540	00+36 31+03		.2 8.6	
6 MAS 300 131/ 50	3845.68N 12632.27E	1200M 200A	349 7W	5 154	540	00+36 31+39		.2 8.4	
7 MAS 300 124/ 39	3852.65N 12633.53E	1500M 500A	357 7W	7 147	540	00+48 32+26		.3 8.1	
8 MAS 300 136/ 23	3844.23N 12553.75E	1500M 500A	239 7W	31 116	490	03+53 36+20		1.0 7.1	
9 AAA 1 146/ 32	3735.02N 12731.00E	1500M 500A	158 7W	117 0	490	14+35 50+55		3.8 3.3	

SCL: 10XMK 82SE 2XWG TANK 0XGUN AMMO 1XALQ119 3XAIM7

ROUTE NAME: W1

TOTAL DISTANCE: 345 TOTAL TIME: 50+55 TOTAL FUEL: 12.0

C

COMBAT MISSION FLIGHT PLAN   W1   TOT:

NAV AID IDENT	CHECKPOINT	ALT MSL AGL	MAG CRS	DIST LEG TO GO	GND SPD	ETE CUM	ETA ATA	FUEL REM BINGO	ACTUAL FUEL
0									
AAA 1	3600.00N								
137/120	12500.00E								
1				108				4.3	
AAA 1	3747.23N	15000M	006	73	300	21+30		11.0	
199/ 13	12556.55E	14000A				21+30		9.7	
2 ** SO **				14				.2	
AAA 1	3757.05N	15000M	059	62	300	01+52		11.7	
120/ 6	12608.99E	14000A				22+22		9.4	
2				6				1.3	
AAA 1	3801.10N	1500M	059	56	480	00+41		10.7	
92/ 14	12614.15E	500A				24+03		9.4	
3				37				1.4	
AAA 1	3824.68N	1500M	058	19	480	04+40		9.3	
63/ 36	12651.02E	500A				28+43		8.0	
4 ** IP **				14				1.5	
AAA 1	3828.72N	1500M	310	4	480	01+48		8.8	
47/ 55	12641.17E	500A				30+31		7.5	
5 ** TGT **				5				.2	
AAA 1	3841.35N	1200M	311	0	540	00+36		8.6	
42/ 45	12636.17E	200A				31+03		7.3	
6				5				.2	
MAS 300	3845.68N	1200M	349	154	540	00+36		8.4	
121/ 50	12632.27E	200A				31+39		7.1	
7				7				.3	
MAS 300	3852.65N	1500M	357	147	540	00+48		8.1	
124/ 39	12630.53E	500A				32+26		6.3	
8				31				1.0	
MAS 300	3844.23N	1500M	229	116	480	03+53		7.1	
166/ 28	12558.95E	500A				36+23		5.3	
9				117				3.3	
AAA 1	3715.02N	1500M	158	0	480	14+35		3.3	
146/ 82	12711.00E	500A				50+55		2.0	

SCL: 10XMK 82SE   2XWG TANK   0XGUN AMMO   1XALQ119   0XAIM7

ROUTE NAME: W1

TOTAL DISTANCE: 345   TOTAL TIME: 50+55   TOTAL FUEL: 12.0

D

```
COMBAT MISSION FLIGHT PLAN        41         TOT:

 NAV      CHECKPOINT     ALT      xMAGx DIST   GNDx ETE  x  FUEL    COMM/RMKS
 AID                     MSL      xCRSx LEG    SPDx CUM  x  REM
 IDENT                   AGL      x   x TO GO     x      x BINGO
 ------  ----------      ---      x---x -----  ---x ---  x -----   ----------
  0                               x   x           x      x
AAA   1    3600.00N               x   x           x      x
137/120   12600.00E               x   x           x      x
                                  x   x           x      x
 1                                x   x 108       x      x   4.3
AAA   1    3747.28N   15000M x006x   76   300  x21-30x  11.0
199/ 13   12556.55E   14000A x   x                 x21-30x   9.7
                             x   x                 x      x
 2 xx SD xx                  x   x   14            x      x    .3
AAA   1    3757.15N   15000M x059x   62   300  x01-52x  10.7
120/  6   12608.79E   14000A x   x                 x23-22x   9.4
                             x   x                 x      x
 2                           x   x    6            x      x   0.3
AAA   1    3801.10N    1500M x059x   56   480  x00-41x  10.7
 92/ 14   12614.15E     500A x   x                 x24-03x   9.4
                             x   x                 x      x
 3                           x   x   37            x      x   1.4
AAA   1    3824.68N    1500M x058x   17   480  x04-40x   9.3
 65/ 36   12651.02E     500A x   x                 x28-43x   8.0
                             x   x                 x      x
 4 xx IP xx                  x   x   14            x      x   0.5
AAA   1    3838.72N    1500M x310x    4   480  x01-48x   8.8
 47/ 55   12641.17E     500A x   x                 x30-31x   7.5
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
 5 xx TGT xx                 x   x    5            x      x    .2
AAA   1    3841.35N    1200M x311x    0   540  x00-36x   8.6
 42/ 45   12636.17E     200A x   x                 x31-08x   7.3
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
 6                           x   x    5            x      x    .2
MAS 300    3845.68N    1200M x349x  154   540  x00-36x   8.4
131/ 50   12632.27E     200A x   x                 x31-39x   7.1
                             x   x                 x      x
 7                           x   x    7            x      x    .3
MAS 300    3852.65N    1500M x357x  147   540  x00-48x   8.1
124/ 39   12630.53E     500A x   x                 x32-26x   6.3
                             x   x                 x      x
 8                           x   x   31            x      x   1.0
MAS 300    3844.20N    1500M x239x  116   480  x03-53x   7.1
160/ 23   12553.95E     500A x   x                 x36-20x   5.3
                             x   x                 x      x
 9                           x   x  117            x      x   3.8
AAA 1      3705.02N    1500M x158x    0   480  x14-35x   3.3
146/ 32   12711.00E     500A x   x                 x50-55x   2.0

SCL: 10XMK 82SE   2XWG TANK   0XGUN AMMO   1XAL0119   3XAIM7

ROUTE NAME:  41

TOTAL DISTANCE:  345   TOTAL TIME:  50-55   TOTAL FUEL:  12.0
```

OBJECTIVE 4 (MOP 4a)

DATA REDUCTION SHEET

i \ j	A	B	C	D
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
Sum= R_j				

PARTICIPANT NO. __________

EASE OF PLANNING QUESTIONNAIRE

Please evaluate the ease of planning for the CAMPS by responding to the following statements. Do so by circling the appropriate term under each.

1. Rate how easy it was for you to get the information you needed from the system.

Terrible Poor Only fair Good Excellent

2. Rate how easy it was for you to use the information provided by the system to plan your mission.

Terrible Poor Only fair Good Excellent

3. Rate how easy to understand and execute, were the procedures for using the system.

Terrible Poor Only fair Good Excellent

4. Rate how well the system provided the level of detail of information you required.

Terrible Poor Only fair Good Excellent

Considering your responses to the above, rate the overall ease of planning a tactical air strike flight plan with the CAMPS.

Terrible Poor Only fair Good Excellent

Comments:

OBJECTIVE 5 (MOP 5)

DATA SUMMARY SHEET

	Terrible	Poor	Only Fair	Good	Excellent
1					
2					
3					
4					
5					

PARTICIPANT NO. ________

CAMPS/EPASS COMPARISON

CAMPS	________	CAMPS/EPASS	________
EPASS	________	CAMPS	________
CAMPS/EPASS	________	EPASS	________

COMMENTS:

OBJECTIVE 6 (MOP 6)

DATA REDUCTION FORM

TEST PARTICIPANT JUDGES	INSTANCE PAIRS					
	CAMPS 1	CAMPS/EPASS 2	EPASS 3	CAMPS 4	CAMPS/EPASS 5	EPASS 6
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
Sum						
Mean						
Key	A	B	C	D	E	F

PARTICIPANT NO. ______________

GENERAL EVALUATION

What was your overall impression of a CAMPS/EPASS type of system as a tool for mission planning?

Poor(unimpressed)_______

Fair_______

Good_______

Excellent(very impressed)_______

What did you like most about the CAMPS/EPASS system?

What did you dislike about the CAMPS/EPASS system?

OBJECTIVE 7

DATA SUMMARY SHEET

RESPONSE TALLEY

Poor	Fair	Good	Excellent

PERCENTAGE

Poor	Fair	Good	Excellent

APPENDIX F

THE CONSTANT SUM METHOD FOR SCALING

Reference: Glenn F. Lindsay, "Scaling with the Constant Sum Method", Naval Postgraduate School, 1980.

The Constant Sum method was used for Objective 6 to scale the property "value to the mission planning process" and locate the instances: CAMPS, CAMPS/EPASS, and EPASS, on the resulting scale. This method requires that the participants agree upon an origin for this scale and this will be assumed. The method will result in a ratio scale. The following procedures adapted from the reference were used.

STEP 1 Each test participant's point assignments recorded on the CAMPS/EPASS comparison form were transferred to the Objective 6 (MOP 6) Data Reduction Form (Appendix E) as follows. The point assignments corresponding to the circled numbers below were recorded in the corresponding column for the test participant on the Data Reduction Form.

CAMPS	1	CAMPS/EPASS	2
EPASS	3	CAMPS	4
CAMPS/EPASS	5	EPASS	6

STEP 2 Compute the mean of each column of the Data Reduction Form.

STEP 3 Record the means (labeled A - F) from the Data Reduction Form into the corresponding cells of the following array. The means become the elements a_{ij} of the matrix $\bar{A}$.

		1 CAMPS	2 CAMPS/ EPASS	3 EPASS
1	CAMPS	50	B	C
2	CAMPS/ EPASS	A	50	F
3	EPASS	D	E	50

$\bar{A}$ MATRIX

STEP 4 Compute a matrix W, with elements

$$w_{ij} = \frac{a_{ij}}{a_{ji}} \quad .$$

STEP 5 Compute scale values S_j, where

$$S_j = \left[\prod_{i=1}^{3} w_{ij} \right]^{1/3} \quad , \; j = 1,2,3,$$

are the geometric column means.

APPENDIX G

DATA SUMMARIES

Page

OBJECTIVE 1 (MOP 1a)

DATA SUMMARY SHEET

<T. TARGET>

Participant Number	P(S) CAMPS	P(S) Manual	D_i $P_c(s) - P_m(s)$	RANK
1	1.00	.15	.85	7
2	1.00	.46	.54	4
3	1.00	1.00	0	
4	1.00	1.00	0	
5	1.00	.55	.45	2
6	1.00	1.00	0	
7	1.00	1.00	0	
8	1.00	.06	.94	10
9	1.00	1.00	0	
10	1.00	1.00	0	
11	1.00	.07	.93	9
12	.57	.07	.50	3
13	1.00	.39	.61	5
14	1.00	1.00	0	
15	—	—	—	—
16	—	—	—	—
17	1.00	.39	.61	6
18	.57	1.00	−.43	−1
19	1.00	1.00	0	
20	.14	1.00	−.86	−8
21	1.00	1.00	0	
22	1.00	1.00	0	
23	1.00	1.00	0	
24	1.00	1.00	0	
N	22	22	22	
Statistic (T)				46
MEANS	$\bar{X}_c = .92$	$\bar{X}_m = .73$	$\bar{d} = .19$	
STD. DEV.	$s_c = .22$	$s_m = .38$	$s_d = .44$	

OBJECTIVE 1 (MOP 1a)

DATA SUMMARY SHEET

<FOR MISSION>

Participant Number	P(s) CAMPS	P(s) Manual	D_i $P_c(s) - P_m(s)$	RANK
1	1.00	.15	.85	12
2	1.00	.46	.54	7
3	1.00	1.00	0	
4	1.00	1.00	0	
5	.19	.55	-.36	2
6	1.00	1.00	0	
7	1.00	1.00	0	
8	1.00	.06	.94	14
9	1.00	1.00	0	
10	1.00	1.00	0	
11	1.00	.07	.93	13
12	.29	.03	.26	1
13	1.00	.27	.73	11
14	1.00	.62	.38	3
15				
16				
17	1.00	.39	.61	10
18	.57	1.00	-.43	-5
19	.61	1.00	-.39	-4
20	.03	.51	-.48	-6
21	.43	1.00	-.57	-9
22	1.00	.44	.56	8
23	1.00	1.00	0	
24	1.00	1.00	0	
N	22	22	22	14
Statistic (T)				79
MEANS	$\bar{X}_c = .82$	$\bar{X}_m = .66$	$\bar{d} = .16$	
STD. DEV.	$s_c = .32$	$s_m = .38$	$s_d = .47$	

OBJECTIVE 2 (MOD 2a)

DATA SUMMARY SHEET

<NUMBER OF ALTITUDE SLICES>

No. of Slices	Talley for Selection As Minimum	Sum of Tallies
3		
4	4 11 12	3
5	1 2 3 5 [illegible] [illegible] 22	7
6	7 [illegible] [illegible] 24	4
7	17 18	2
8	9	1
9	21	1
10	23	1

OBJECTIVE 2 (MOP 2b)

Page 1 of 2

DATA CONSOLIDATION FORM

(RELATIVE WORTH OF LISTED ALTITUDES)

①	②																								③
ALTITUDES	RELATIVE WORTH BY TEST PARTICIPANT																								SUM (S)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
25										1.096															1.096
50														1.429		.211									1.640
75										.546															.546
100	1.429	1.429	1.429	1.429	1.429	1.429	.846	.846	1.429	1.429	1.429	.646	1.429	.846		.646		.100	1.429	1.429	.846	1.429		1.429	24.782
150										.167						.336					1.429	.419			2.411
200	.646			1.029	1.096	.846	1.429	1.429	1.429	.111		1.429	.846	.250		1.429	1.429	1.429	1.096	1.096	.211	1.429	1.429		20.638
250			1.096							.167												.419			1.742
300	.100			.846									1.429	.846		.479	1.096	1.096	.100	.646	.111	.646	.100	1.429	9.149
350																						.336			.336
400							1.429										.846				1.429	.336			4.04
500	1.429	1.429	1.429	1.429	1.429	1.429		1.429	1.429	1.429	1.429	1.429	.229	1.429		1.429	1.429	1.429	1.429	1.429	1.429	1.429	1.429	1.429	30.488
600							1.096						.200												1.296
700													.916	.646										1.096	2.721
750								1.096																	1.096
800						.211							.450												.666
900													.646											.846	1.492
1000	1.429	1.429	1.429	1.429	1.429	1.429	1.429	1.429	1.096	1.429	1.429	1.429		1.429		1.429	1.429	1.429	1.429	1.429	1.096	1.096			26.152
1100													.167											.646	.813
1200				.111									.419												.640
1500				.419	.864	1.096	.646	.419		.143			.111					.846	.846					.419	5.489
1800													.100												.100
2000			.100		.646	.336	.419	.646		.336			.125	.419			.646							.336	4.129

OBJECTIVE 2 (MOP 2b)

Page 2 of 2

DATA CONSOLIDATION FORM

<RELATIVE WORTH OF LISTED ALTITUDES>

①	②																								③
ALTITUDES	RELATIVE WORTH BY TEST PARTICIPANT																								SUM (S)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
2500	.419		.546	.646	.419		.336						.211					.646						.211	3.554
3000		.646	.300		.336	.130	.211						.100				.419							.100	2.272
4000			.211		.211											.100	.336								.858
5000	1.096	.846	.535	.336	.100	.646		.336	.846	.211	1.096	1.096		.336		.446	.211	.336	.211	.100		.100			9.434
6000			.111																						.111
7500	.336		.368																						.704
8000			.111													.100									.211
10000	.846	1.096	.336	.100		.419	.100	.211	.646	.211	.846	.846		.211		.746	.100	.419	.419	.200	.646	.100	.419		10.057
12500														.100		.100									.200
15000	.211	.419						.100	.419	.100	.646	.419								.646	.419		.646		4.161
20000		.336							.336	.100	.419	.336						.211	.336	.211	.100		.336		2.731
25000		.211							.211		.336	.211								.419			1.096		2.544
28000																							.336		.336
30000		.100							.100		.211	.100							.646	.336			.646		2.134
33000																							.336		.336
35000											.100												.211		.311

OBJECTIVE 2 (MOP 2b)

DATA CONSOLIDATION FORM

(RELATIVE WORTH OF INDEX ALTITUDES)

①	②																								③
ALTITUDES	RELATIVE WORTH BY TEST PARTICIPANT																								SUM (S)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
100	1.429	1.429	1.429	1.429	1.429	1.429	.846	.846	1.429	1.429	1.429	.646	1.429	1.429		.646		.100	1.429	1.429	.846	1.429		1.429	25.365
200	.646			1.029	1.096	.846	1.429	1.429	1.429	.111		1.429	.846	.250		1.429	1.429	1.429	1.096	1.096	1.429	1.429	1.429		21.856
300	.100		1.096	.846						.167			1.429	.846		.429	1.096	1.096	.100	.646	.336	.646	.100	1.429	10.412
400							1.429										.846				1.429	.336			4.04
500	1.429	1.429	1.429	1.429	1.429	1.429	1.096	1.429	1.429	1.111	1.429	1.429	.919	1.429		1.429	1.429	1.429	1.429	1.429	1.429	1.429	1.429	1.429	31.834
1000	1.429	1.429	1.429	1.429	1.429	1.429	1.429	1.429	1.096	1.429	1.429	1.429	.646	1.429		1.429	1.429	1.429	1.429	1.429	1.096	1.096		.846	24.023
1500				.419	.164	1.096	.646	.419		.143			.111					.846	.846					.419	5.181
2000			.100		.646	.336	.419	.646		.336			.125	.419			.646							.336	4.121
3000	.419	.646	.546	.646	.419	.100	.336						.211				.419	.646						.211	4.771
4000			.211		.211											.100	.336								.858
5000	1.096	.846	.535	.336	.100	.646		.336	.846	.211	1.096	1.096		.336		.996	.211	.336	.211	.100		.100			7.454
10 000	.846	1.096	.360	.100		.419	.100	.211	.646	.211	.846	.846		.211		.146	.100	.419	.419	.200	.646	.100	.419		7.151
15 000	.211	.419						.100	.419	.100	.646	.419						.211	.646	.646	.419		1.096		5.512

OBJECTIVE 3 (MOP 3a)

DATA SUMMARY SHEET

<DISPLAY CHARACTERISTICS>

	POOR	ONLY FAIR	GOOD	EXCELLENT
COLOR		8 23	3 4 5 [illegible] [illegible] [illegible] [illegible] 16 19 [illegible] 15 17	1 [illegible] [illegible] [illegible] [illegible] 20 [illegible] [illegible] [illegible] [illegible]
INFO CONTENT		7	2 3 [illegible] [illegible] [illegible] 19 15 16 [illegible]	1 5 8 21 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 18 [illegible] [illegible]
LINE TEXTURES		7 12 20	1 3 4 5 [illegible] 9 10 14 15 16 21 19 17 12	2 6 11 13 23 22 [illegible]
SCREEN SIZE	8	19 9 12 15 16	1 2 3 4 5 7 19 10 6 14 [illegible] 18 20 [illegible] 22 23	17 13
MAP SCALES		23	8 22 4 5 3 15 9 12 10 14 18 20 16 24	1 2 6 [illegible] 11 13 21 17 19
OVERALL			1 2 3 4 7 14 8 12 10 9 15 16 19 20 21	5 6 11 13 17 18 22 23 24

OBJECTIVE 3 (MOP 3b)

CONSOLIDATED COMMENTS ON THE CAMPS DISPLAY

Note: If more than one participant made a comment, the number is indicated in parentheses following the comment.

1. The display is an effective aid.

2. Would like to have the cursor stay visible and be able to move it in real-time.

3. The display should be larger. (5)

4. Display fuel, distance, etc., for a candidate point.

5. Be able to change altitude slice display while planning initial route. (5)

6. Have display change automatically when altitude is changed.

7. Display leg altitudes on route.

8. Labeling cluttered screening, may be related to size.

9. Need a color legend.

10. Use letters for checkpoints vice numbers.

11. Need terrain/map features to aid in orientation. (4)

Note: The system has the ability to add many features. This capability was used only to a very limited extent for the test. Increasing displayed features also increases clutter.

12. Course line too broad or blocks too big to distinguish their intersection.

13. Would like to have point location of threats without coverage.

14. Be able to shift threat scales more easily.

15. Be able to print route on a map.

16. Make encyclopedic information on aircraft characteristics, weapons, maneuvers to degrade/defeat weapons, etc., available in the system.

OBJECTIVE 4 (MOP 4a)

DATA REDUCTION SHEET

<KNEEBOARD CARD RANKINGS>

i \ j	A	B	C	D
1	4	3	2	1
2	4	2	1	3
3	3	1	2	4
4	4	3	2	1
5	4	2	3	1
6	4	3	1	2
7	4	3	2	1
8	4	3	2	1
9	3	1	2	4
10	3	2	1	4
11	3	2	1	4
12	3	2	4	1
13	4	3	2	1
14	4	3	2	1
15	4	3	1	2
16	4	3	1	2
17	4	2	3	1
18	4	3	2	1
19	4	3	2	1
20	4	3	2	1
21	4	3	2	1
22	2	1	3	4
23	4	3	2	1
24	3	4	2	1
Sum= R_j	83	61	47	44

OBJECTIVE 4 (MOP 4b)

CONSOLIDATED COMMENTS ON THE KNEEBOARD CARDS

Note: If more than one participant made a comment, the number is indicated in parentheses following the comment.

1. Spread the information out.

2. Put only 6-7 points per card. (2)

3. Include True Course and Magnetic Course for the A-6. (3)

4. Need larger print.

5. Delete NAVAID information since not available in combat. (3)

6. Use MSL only.

7. Show speed changes only.

8. Space horizontally more.

9. Like actual fuel notation column.

10. Don't need ETA/ATA or actual fuel column. (4)

11. Use MSL for altitudes above 1000 ft. and AGL for altitudes below 1000 ft.

12. Use only one altitude entry, AGL or MSL, not both.

13. Like the bingo fuel entry. (8)

14. Want checkpoint plain language identifier.

15. Reverse ETE and cumulative times.

16. A-4 pilots don't need kneeboard cards. Information must be transferred to map. Therefore, format isn't critical. (2)

17. Put card information on heads-up display (HUD)

18. Like highlighting of various items of information. (3)

19. Don't need magnetic variation. (5)

20. Need magnetic variation.

21. Want true air speed instead of ground speed. (2)

OBJECTIVE 5 (MOP 5)

DATA SUMMARY SHEET

<EASE OF USE>

	Terrible	Poor	Only Fair	Good	Excellent
1			19, 20	3, 24, 4, 8, 7, 12, 9, 15, 16	1, 2, 21, 13, 5, 10, 17, 6, 11, 22, 14, 18, 23
2			4	24, 9, 15, 8, 16, 12	1, 2, 21, 17, 7, 6, 10, 23, 13, 14, 5, 22, 11, 3, 20, 18, 19
3				24, 2, 3, 8, 9, 4, 5, 12, 18, 15, 6, 16, 7, 19	1, 21, 10, 13, 14, 22, 11, 17, 20, 23
4			16	24, 1, 2, 3, 5, 9, 4, 12, 15, 10	6, 21, 22, 8, 13, 7, 14, 20, 11, 17, 18, 19, 23
5				9, 3, 24, 12, 4, 16, 15, 7, 10	1, 21, 2, 13, 18, 5, 6, 19, 8, 11, 22, 14, 17, 20, 23

OBJECTIVE 6 (MOP 6)

DATA REDUCTION FORM
(CAMPS/EPASS COMPARISON)

TEST PARTICIPANT JUDGES	INSTANCE PAIRS					
	CAMPS 1	CAMPS/EPASS 2	EPASS 3	CAMPS 4	CAMPS/EPASS 5	EPASS 6
1	30	70	20	80	90	10
2	20	80	50	50	100	0
3	60	40	20	80	80	20
4	50	50	40	60	70	30
5	0	100	25	75	100	0
6	40	60	25	75	100	0
7	40	60	60	40	60	40
8	40	60	30	70	70	30
9	20	80	40	60	100	0
10	0	100	10	90	100	0
11	40	60	20	80	90	10
12	25	75	10	90	75	25
13	10	90	20	80	70	30
14	40	60	40	60	75	25
15	30	70	60	40	70	30
16	25	75	25	75	75	25
17	40	60	40	60	70	30
18	75	25	25	75	75	25
19	0	100	20	80	100	0
20	30	70	40	60	80	20
21	25	75	25	75	75	25
22	100	0	0	100	100	0
23	25	75	50	50	75	25
24						
Sum	765	1535	695	1605	1920	380
Mean	33.3	66.7	30.2	69.8	83.5	16.5
Key	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

OBJECTIVE 7

DATA SUMMARY SHEET

<OVERALL IMPRESSION>

RESPONSE TALLEY

Poor	Fair	Good	Excellent
		4 9 10 15 [illegible] 17 24	1 2 3 5 5 [illegible] 8 [illegible] [illegible] [illegible] [illegible] 14 [illegible] 2[illegible] 2[illegible] 22 23

PERCENTAGE

Poor	Fair	Good	Excellent
		29%	71%

OBJECTIVE 8 (MOP 8)

CONSOLIDATED COMMENTS ON CAMPS/EPASS SYSTEM

Note: If more than one participant made a comment, the number is indicated in parentheses following the comment.

LIKES

1. Saving of manual calculations. (5)

2. Interpretation of terrain effects.

3. Mission information printout. (3)

4. Threat display at the different altitudes. (14)

5. Target area display.

6. Ability to test alternative ECM options on EPASS. (2)

7. Flexibility of the system while planning. (2)

8. Easy to operate. (2)

9. EPASS probability charts.

10. EPASS threat breakdown by site.

DISLIKES

1. Sensitivity to intelligence spoilage. (6)

2. Unknown terrain accuracy. (Unverified)

3. Slow response of system. (4)

4. System too bulky.

5. Doesn't display major terrain. [See note for Comment 11, Objective 3 (MOP 3b)]

6. Concern about ruggedness.

7. Screen too small. [See Comment 3, Objective 3 (MOP 3b)]

8. Not available at squadrons. (3)

9. Would not be responsive enough for CAS on-call missions since the threat changes so fast.

10. Didn't like touch panel menu.

11. Lack of correlation between display and map.

12. Disliked the limitation of only one candidate point at a time.

13. Wanted to be able to change altitude slice display while planning route. [See Comments 5 and 6 of Objective 3 (MOP 3b)] (2)

14. Felt there was some confusion in operating system.

APPENDIX H

DETAILS OF ANALYSIS

TAB 1 to APPENDIX H

WILCOXON MATCHED-PAIRS SIGNED-RANK TEST

Summary of the Procedure

1. For each test participant determine the signed difference, (D_i), between the probability of survival for CAMPS, $P_c(s)$, and the probability of survival for manual missions, $P_m(s)$.

2. Rank the differences without regard to the sign. Smallest difference is ranked first, largest is ranked last.

3. Replace the signs.

4. Compute T = sum of the positive ranks.

5. Determine N = number of differences, D_i, not equal to zero.

6. Use T and N for table look-up of significance level.

Table Reference: DIXON-MASSEY, Introduction to Statistical Analysis, McGraw-Hill. P. 543 Table A-19.

INTERVAL SCALES FROM ORDINAL JUDGMENTS

1. Test participant ordinal responses are tallied into an f_{ij} array where each element, f_{ij}, is the number of participants who ranked alternative j above alternative i, i.e.,

i \ j =	A	B	C	D
A	--	f_{AB}	f_{AC}	f_{AD}
B	f_{BA}	--	f_{BC}	f_{BD}
C	f_{CA}	f_{CB}	--	f_{CD}
D	f_{DA}	f_{DB}	f_{DC}	--

2. A p_{ij} array is constructed where

$$p_{ij} = \frac{f_{ij}}{f_{ij} + f_{ji}}$$

Diagonal elements of the p_{ij} array are set to 0.5.

3. A Z_{ij} array is then computed where each Z_{ij} element is the standard normal percentile corresponding to the p_{ij}. For $.02 > p_{ij} > .98$, the Z_{ij} cell is left empty.

4. If the Z_{ij} array contains no empty cells, then the column averages can be used as scale values, S_j, for the alternatives.

$$S_j = \sum_{i=A}^{D} Z_{ij}, \quad j = A,B,C,D$$

5. If the Z_{ij} array has empty cells, then a least squares method must be used for columns with empty cells. For complete columns, the column average may be used as the scale value. For those columns with empty cells, a set of linear equations of the form,

$$n_j s_j - \sum_{i \in \Phi_j} s_i = \sum_{i \in \Phi_j} Z_{ij}$$

must be written where Φ_j denotes the set of n elements in column j of the Z_{ij} array. Substitute the scale values for the complete columns and solve the set of simultaneous equations to obtain the remaining scale values.

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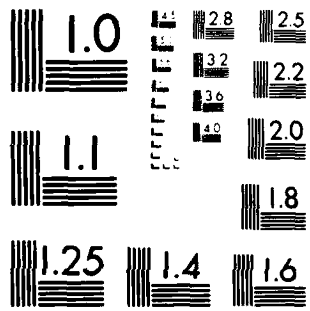

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

TAB 3 to APPENDIX H

KENDALL'S COEFFICIENT OF CONCORDANCE

Summary of Procedure

1. The columns of the Objective 4 (MOP 4a) Data Summary Sheet were summed to yield the values R_j, for j = A,B,C,D.

2. Compute $\bar{R}$, where

$$\bar{R} = \frac{\Sigma R_j}{4}$$

3. Calculate the sum of squared deviations.

$$s = \Sigma (R_j - \bar{R})^2$$

4. Calculate

$$K = \frac{k^2(N^3-N)}{12} = 2880$$

where k = number of judges = 24

N = number of alternatives ranked = 4

5. Compute the Kendall Coefficient, W

$$W = \frac{s}{K} = \frac{s}{2880}$$

6. For small samples, $N \leq 7$, the Kendall coefficient is tested for significance as follows:

If the observed s is equal to or greater than that shown in Table R of Siegel, then the hypothesis of independent rankings may be rejected at the particular level of significance.